

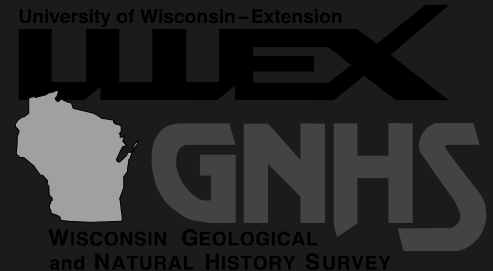
Uncovering the Quality and Quantity Issues of Wisconsin's *Buried Treasure*



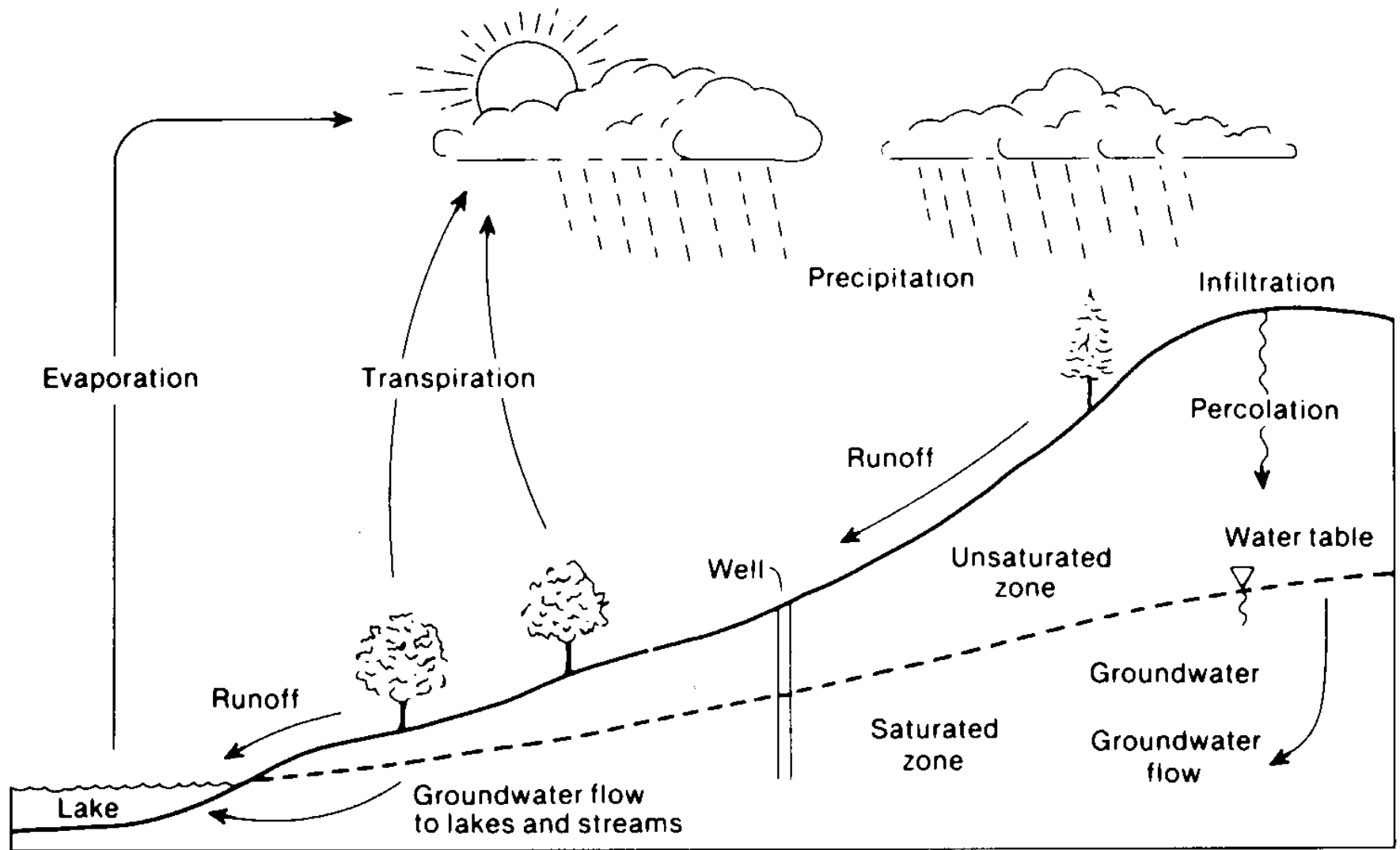
Jim Krohelski - U.S. Geological Survey

George Kraft – Central Wisconsin Groundwater Center

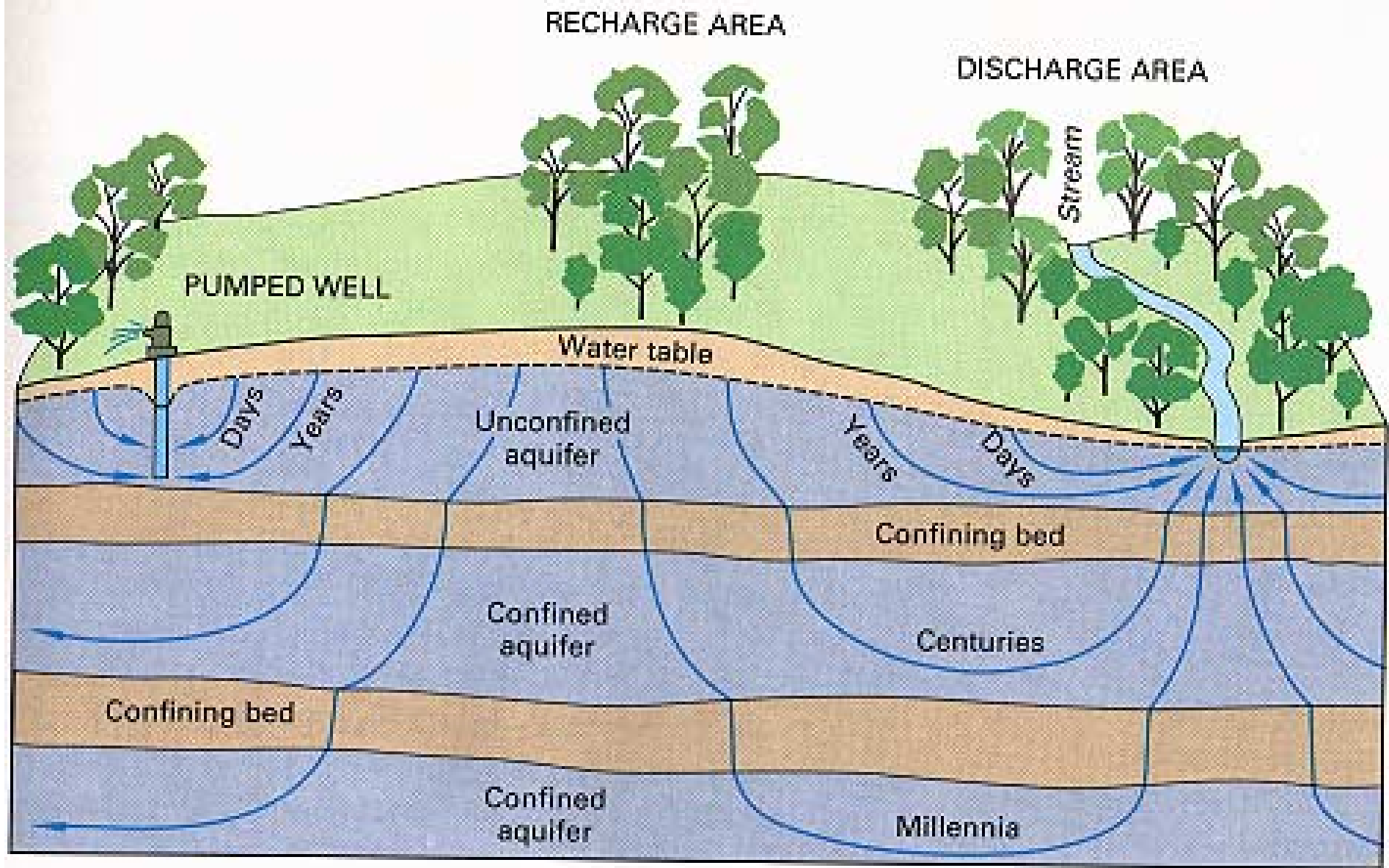
Ken Bradbury - Wisconsin Geological and Natural History Survey



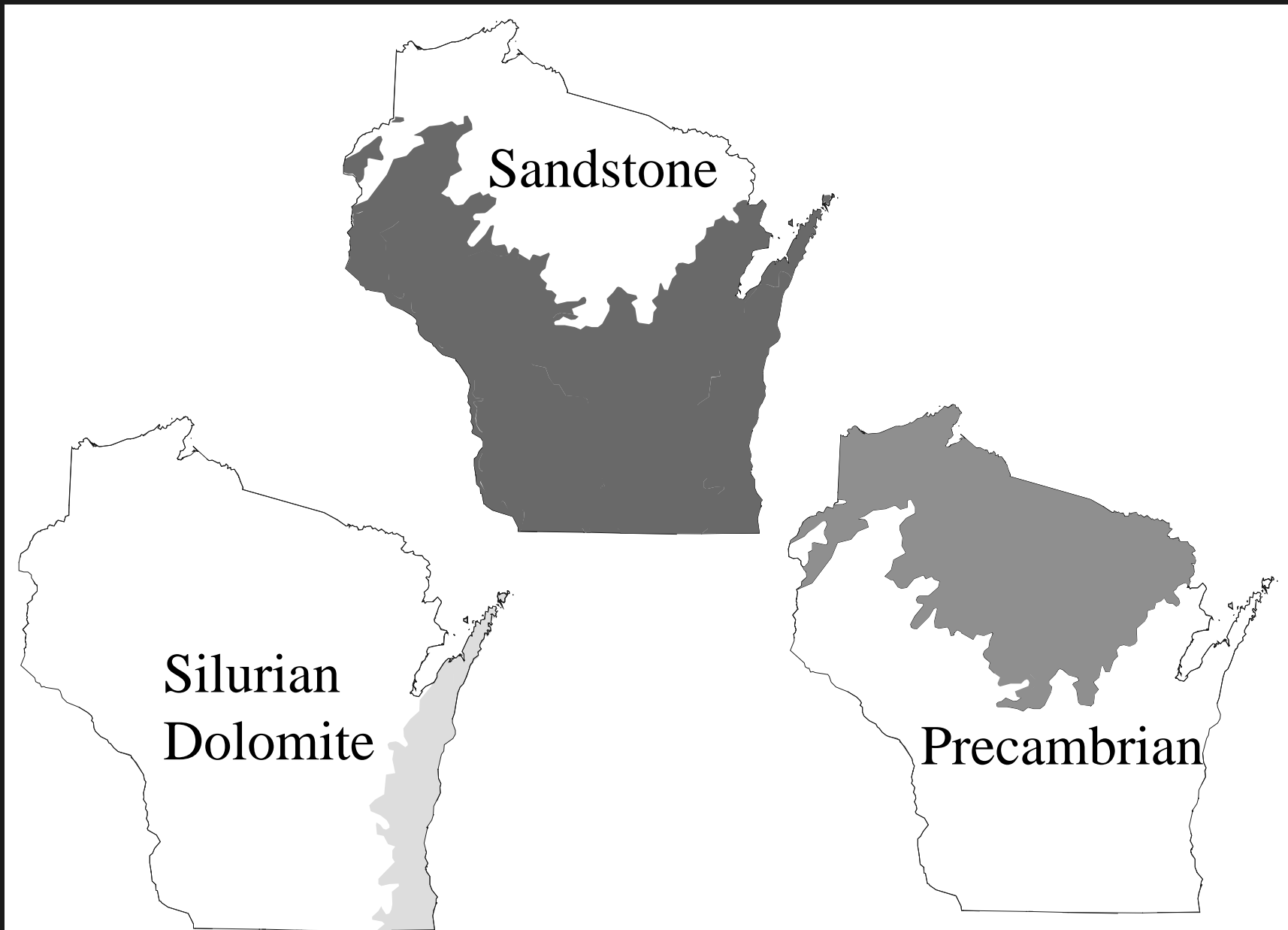
All water on earth is part of the water cycle



Groundwater moves from recharge areas to discharge areas

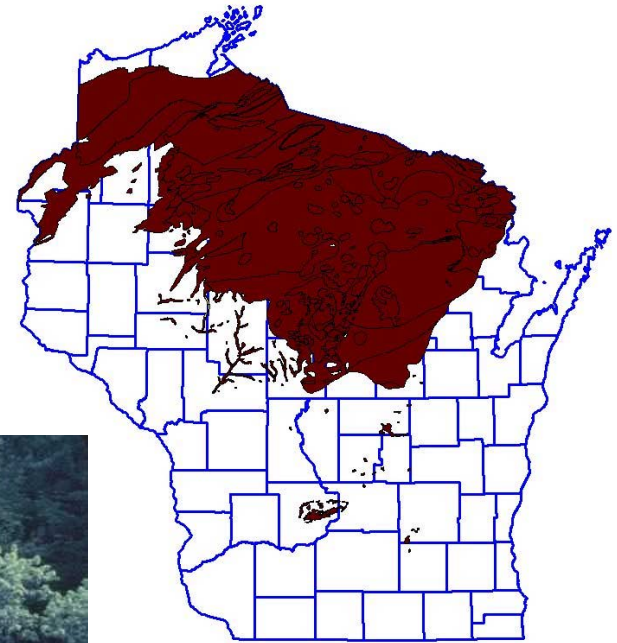


Wisconsin's Aquifers



PreCambrian aquifer:

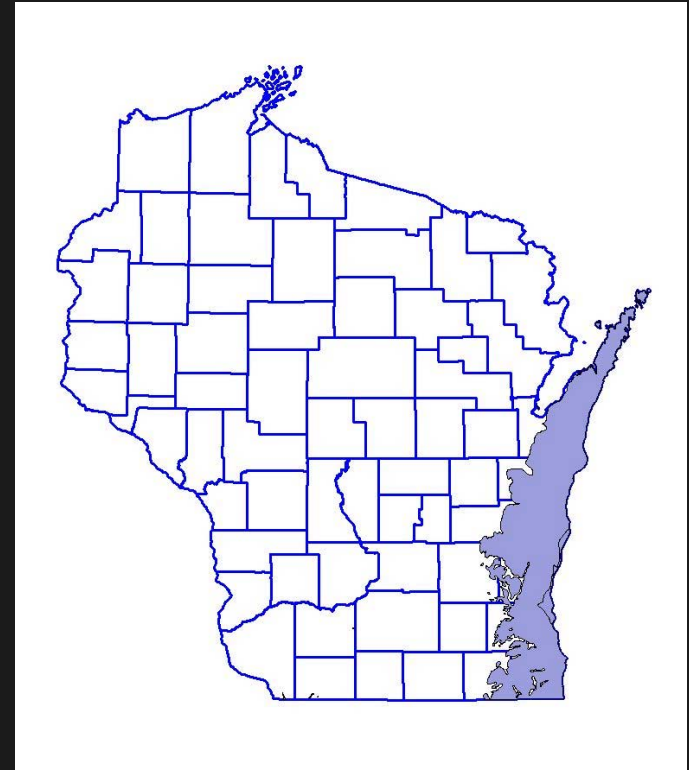
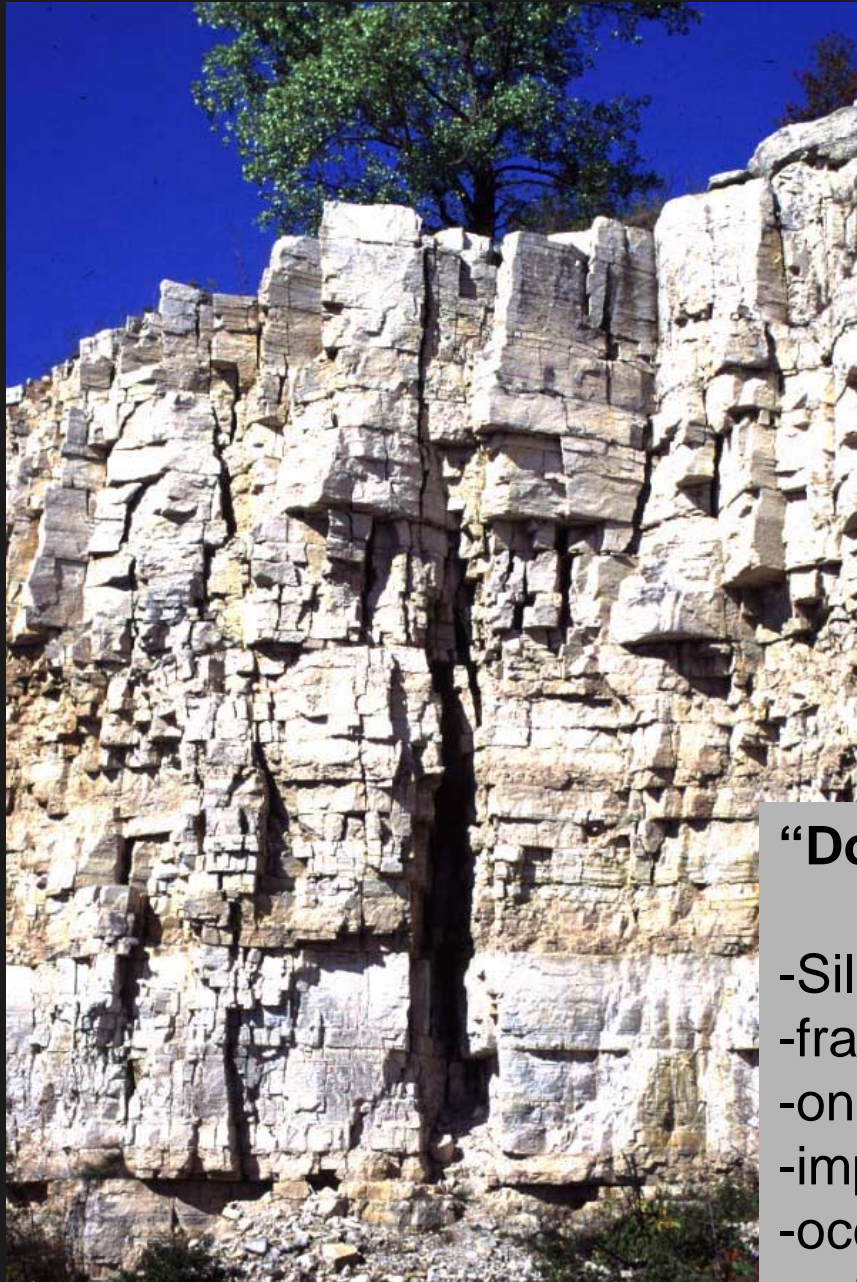
- crystalline (granite, quartzite)
- fracture dominated flow
- generally low well yields



“Sandstone” aquifer:

- sandstone, dolomite
- regionally extensive
- excellent aquifer
- porous flow
- most high-capacity wells
- occurs beneath shale in east





“Dolomite” aquifer:

- Silurian dolomite
- fracture dominated flow
- only present in east
- important for municipal and domestic wells
- occurs above Maquoketa Shale
- extremely vulnerable if exposed

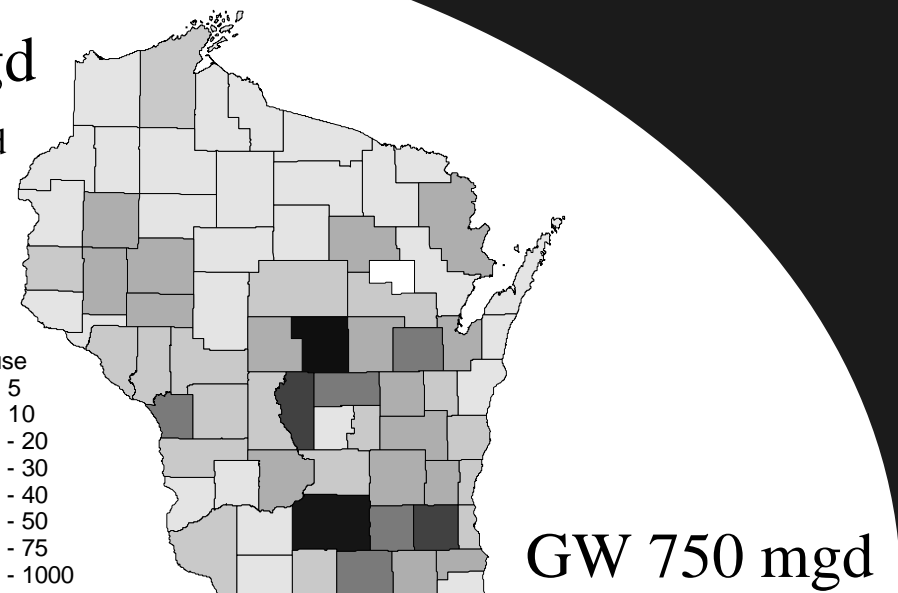
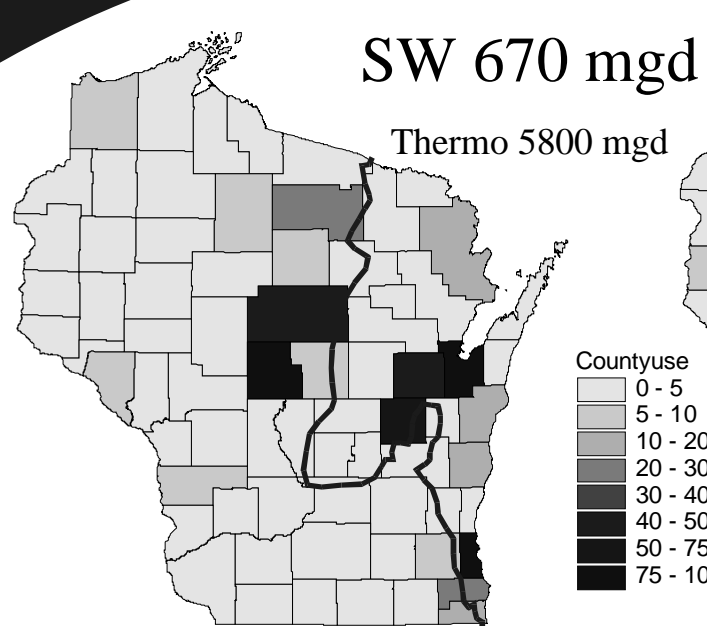


A map of the central United States, specifically the Midwest, showing the distribution of sand and gravel. The land area is colored yellow, while water bodies (Great Lakes, Mississippi River, and surrounding oceans) are colored blue. A black outline indicates the state boundaries. An arrow points from the text 'Sand and Gravel' to a specific yellow-colored region in the central part of the map, likely representing the Sand and Gravel aquifer.

Sand and Gravel

Sand and gravel aquifer:

- uppermost aquifer
- sand and gravel
- discontinuous
- vulnerable

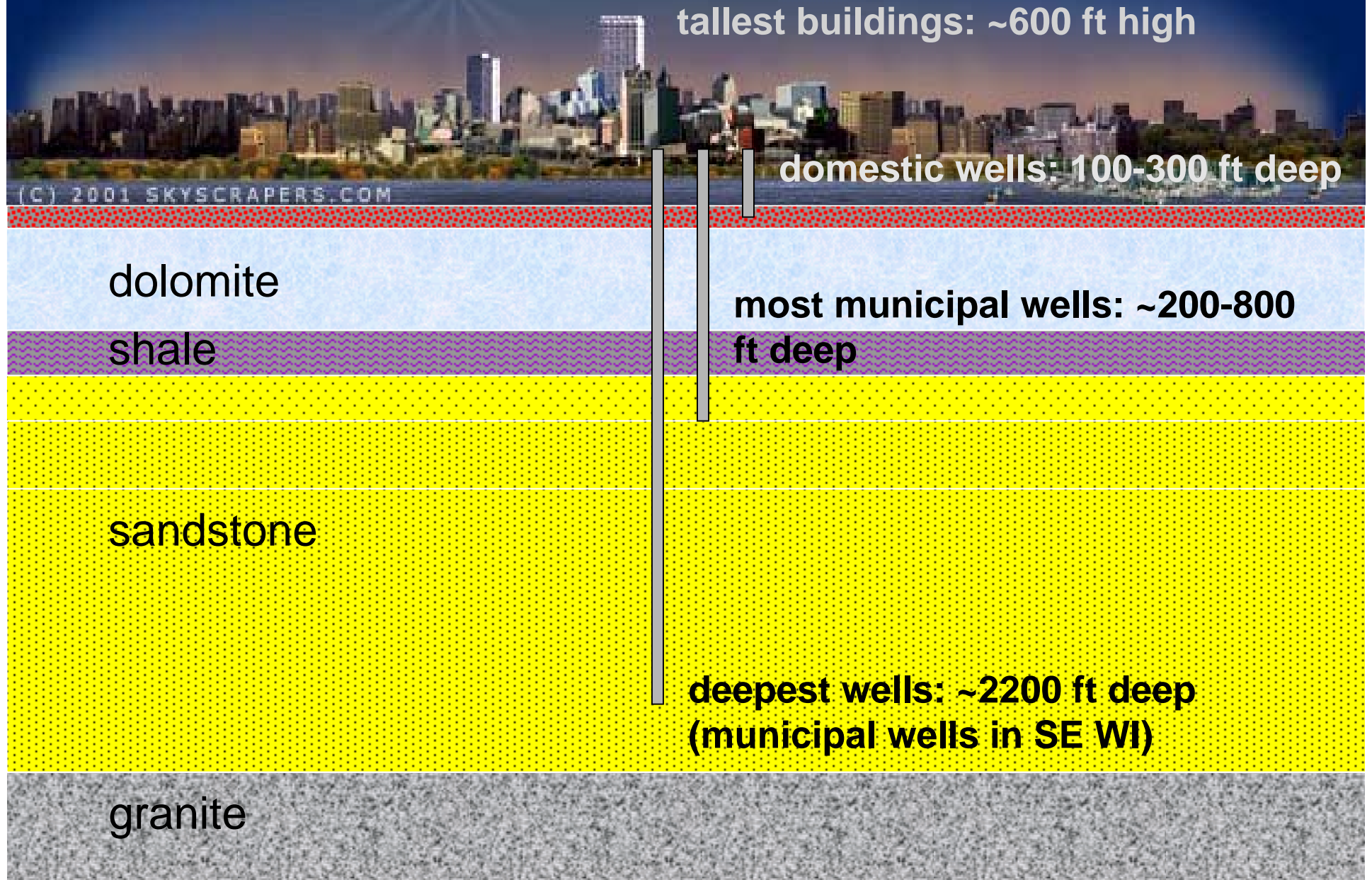


Sandstone 365
 Sand and Gravel 330
 Silurian Dolomite 45
 Precambrian 10

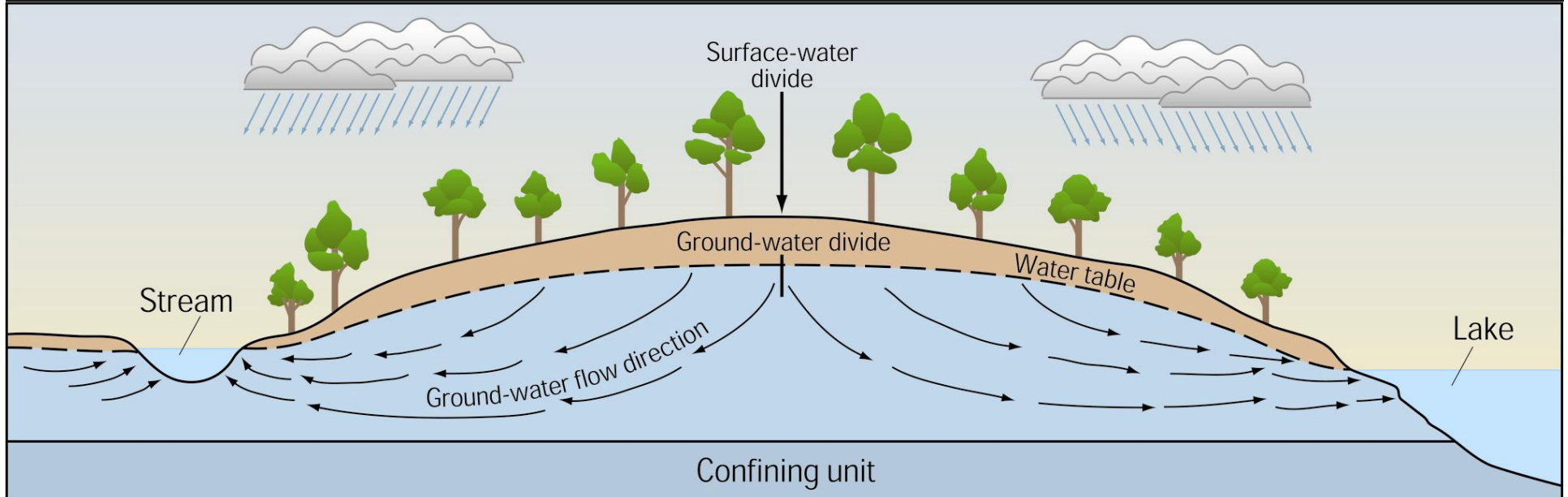
Total in mgd 750

Ellefson and others, 1997

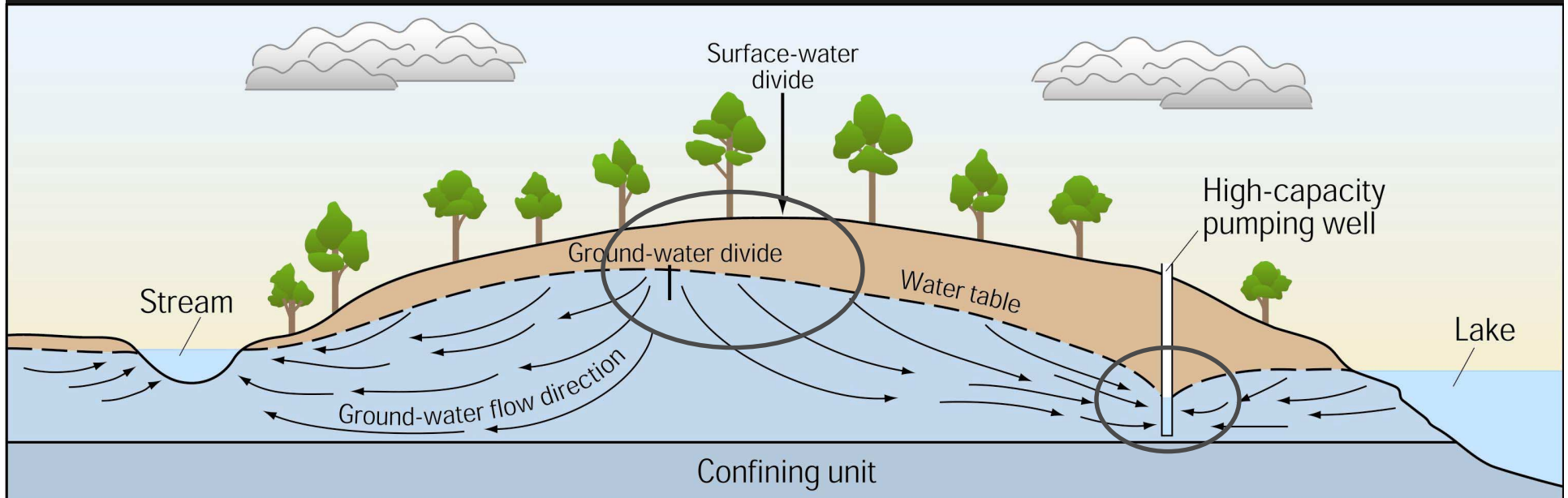
Relative well depths



Natural

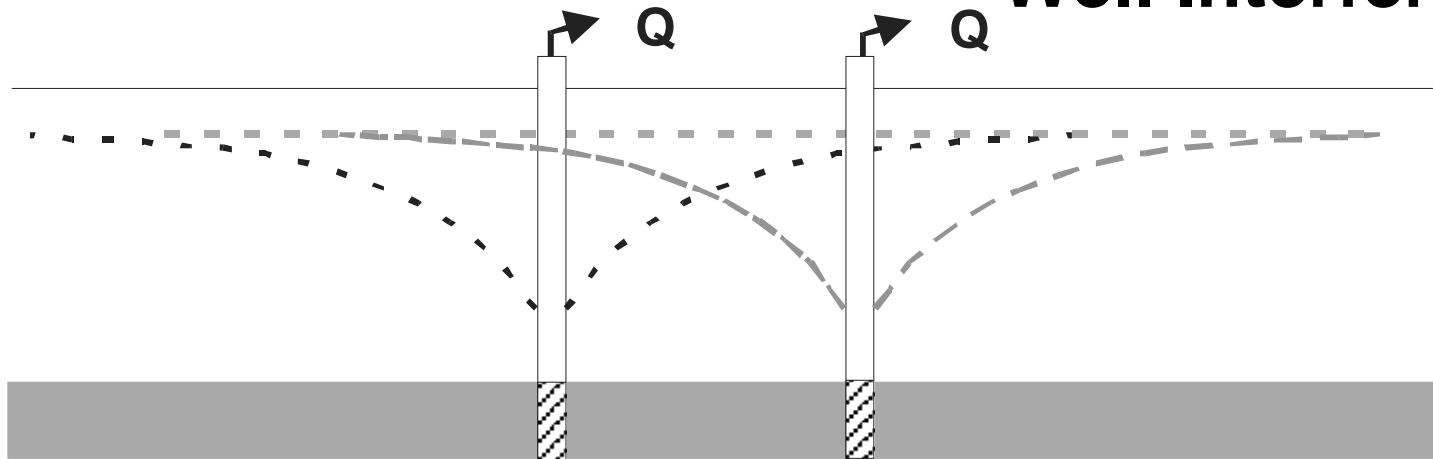


Affected By Pumping

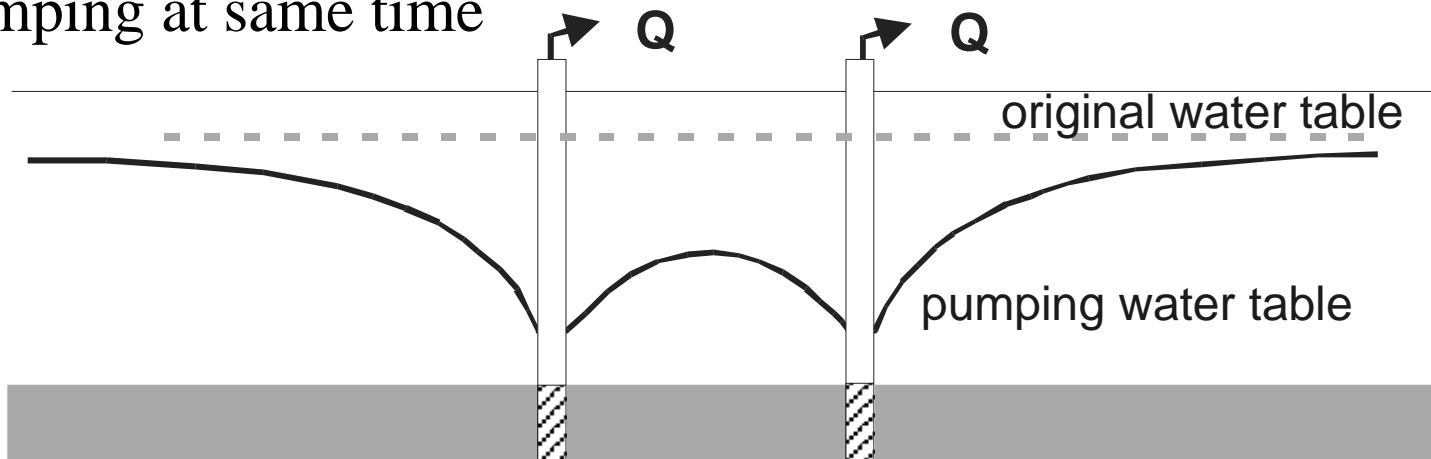


Wells **NOT** pumping at same time

Well Interference



Wells pumping at same time



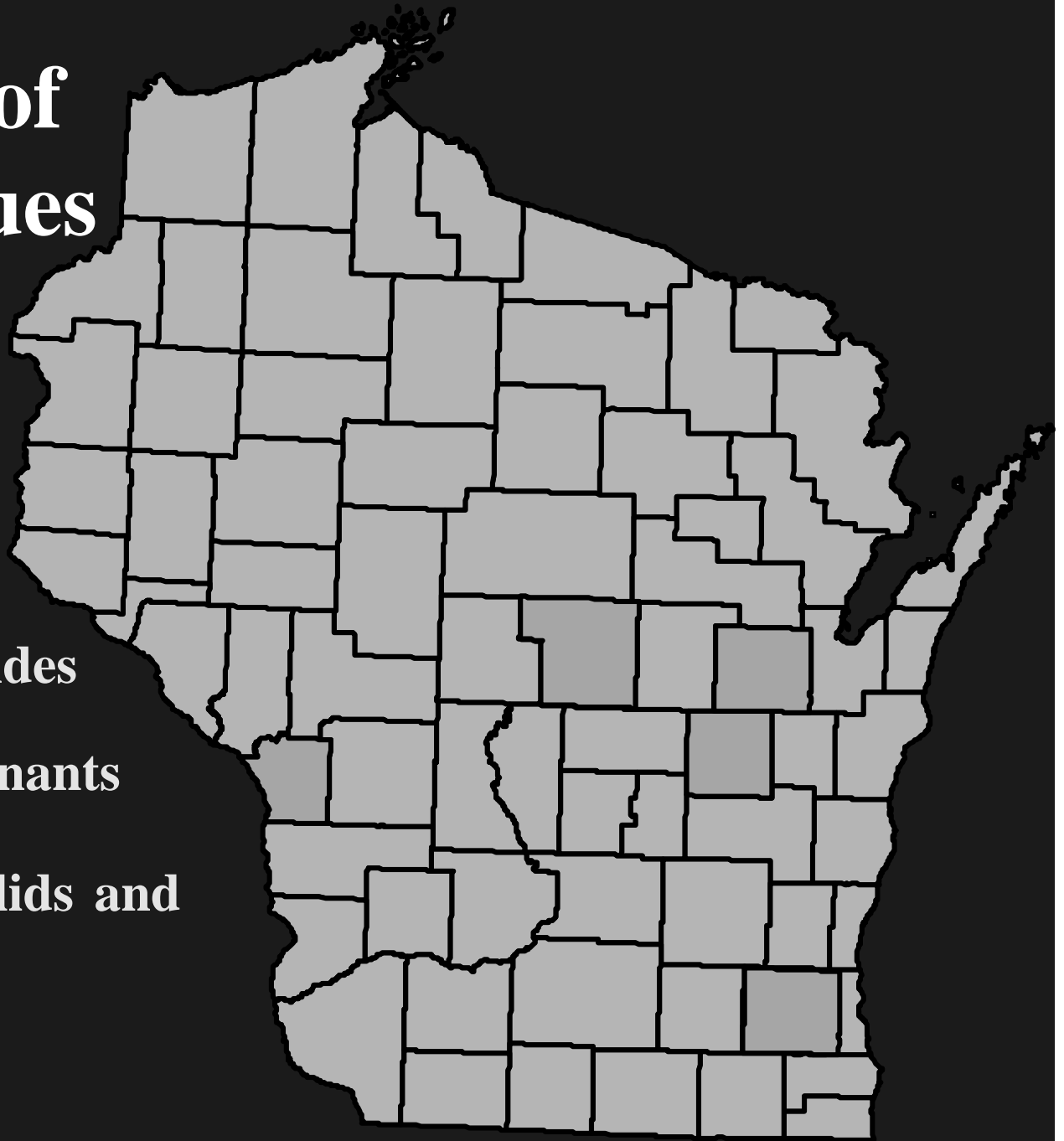
Examples of Quality Issues

Nitrates and Pesticides

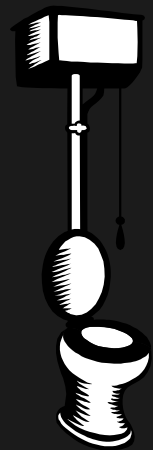
Emerging Contaminants

Total Dissolved Solids and
Radioactivity

Arsenic

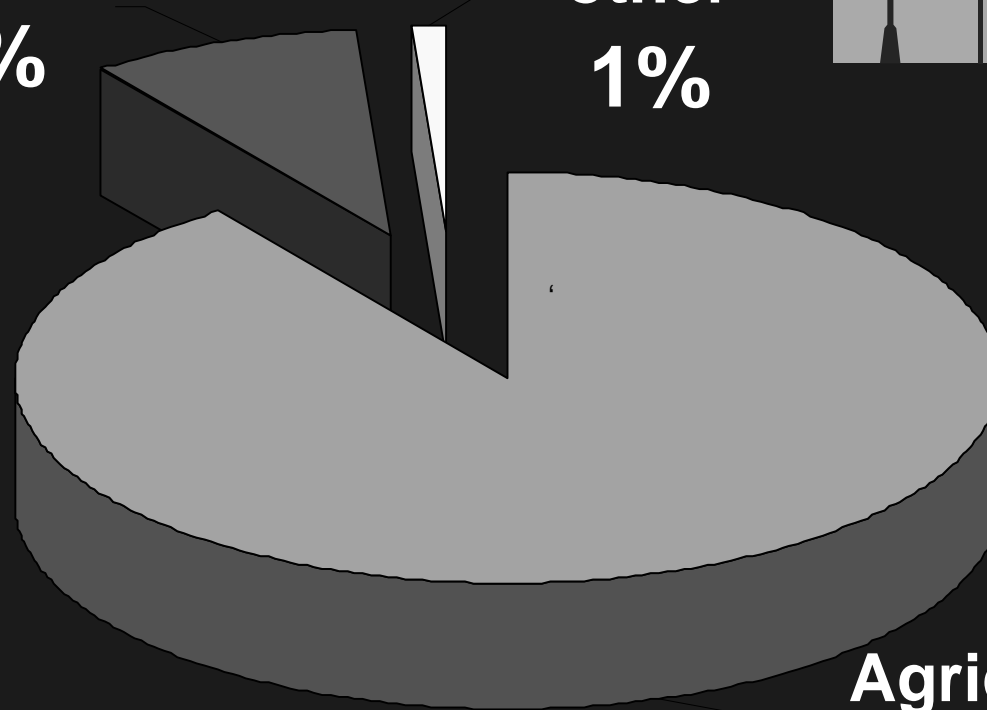
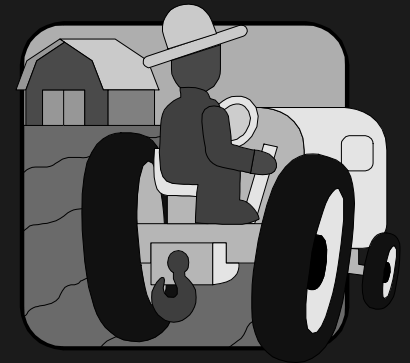


Sources of Nitrate Loading



Septics
9%

**Lawns/
other**
1%

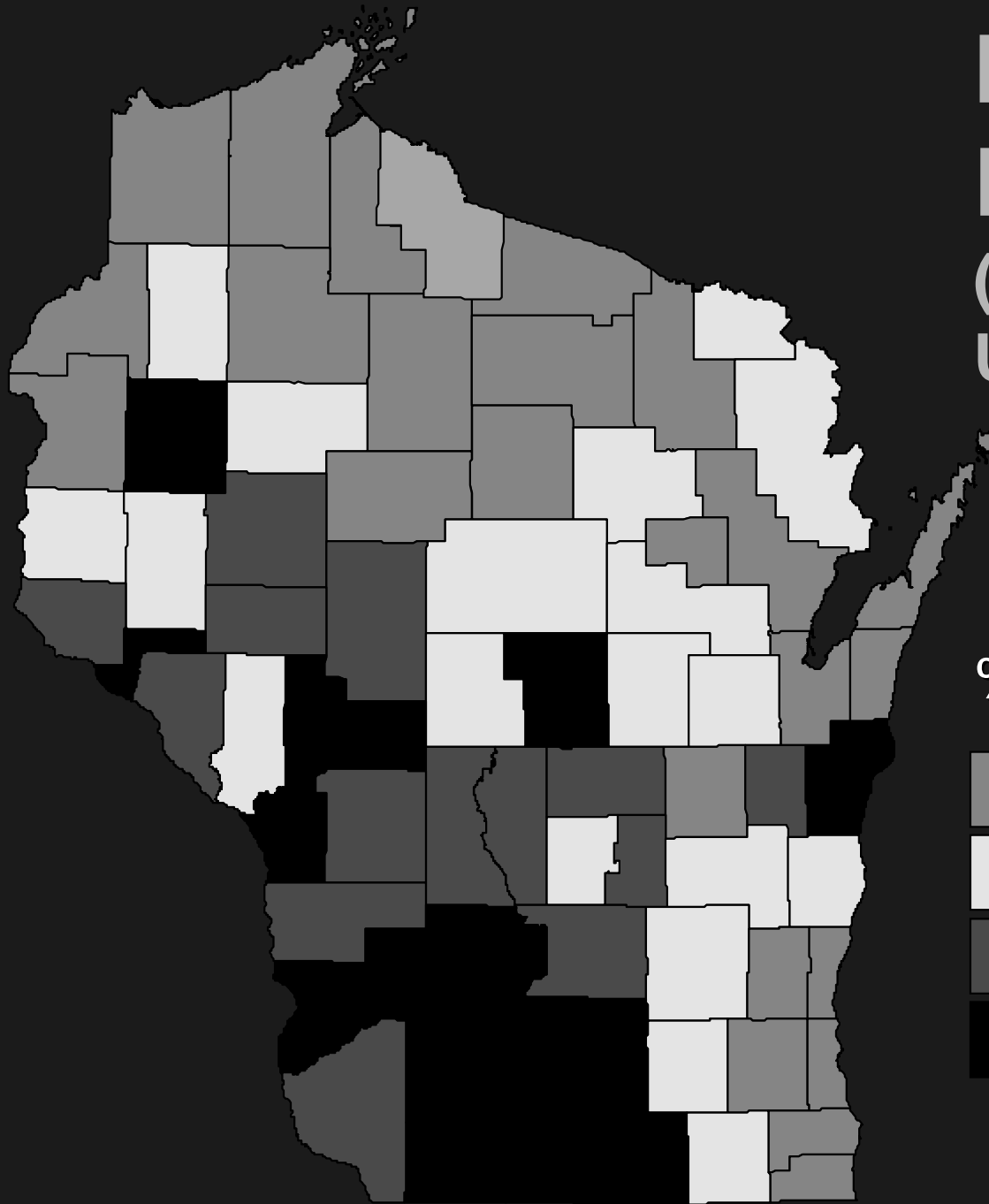
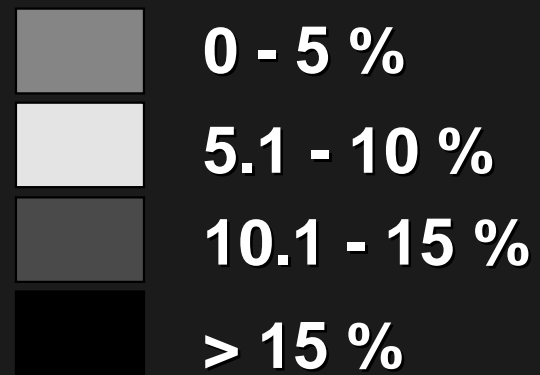


Agriculture
90%

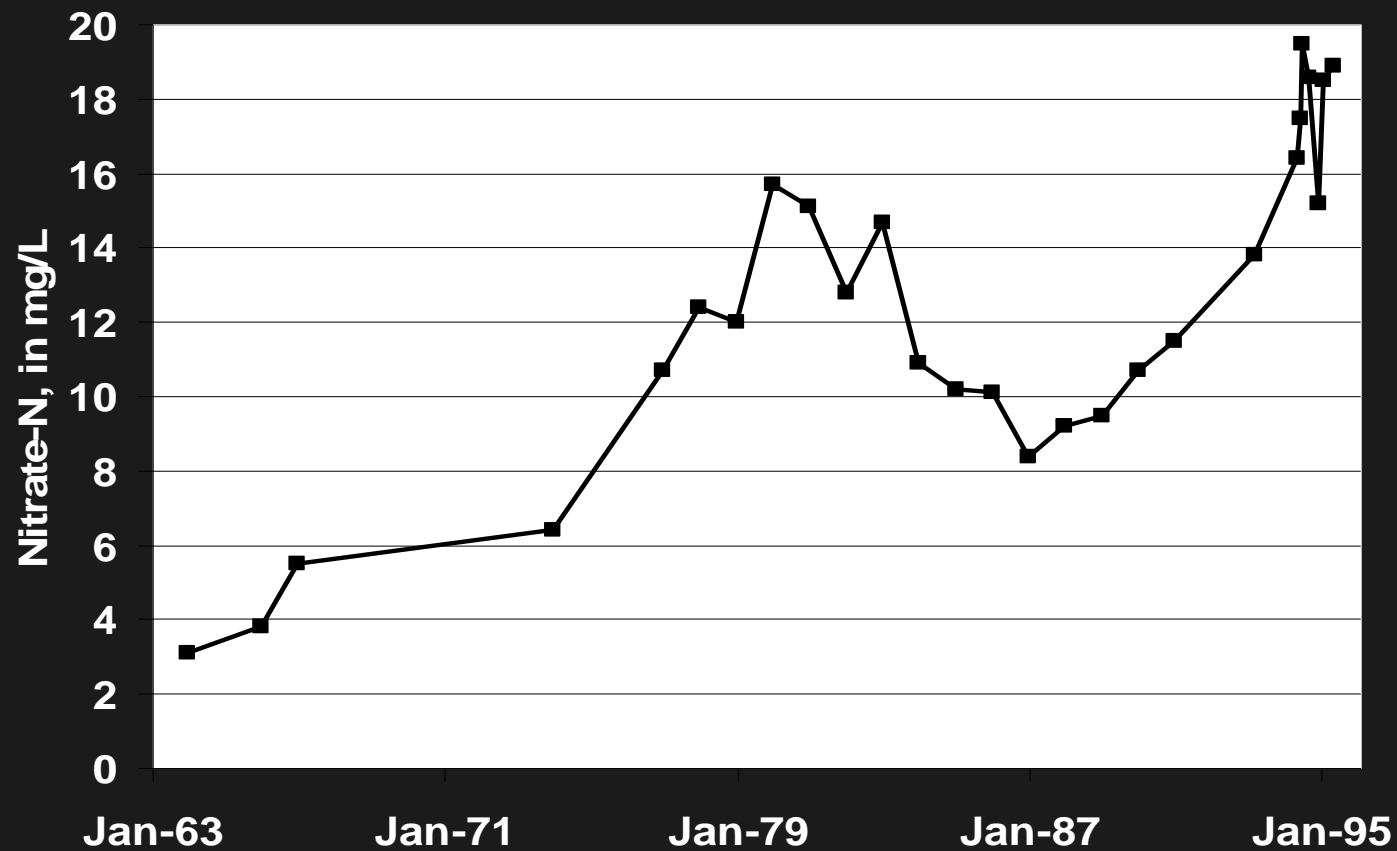
Shaw, 1994

Nitrate Exceedences (CWGC, WGNHS, USGS data)

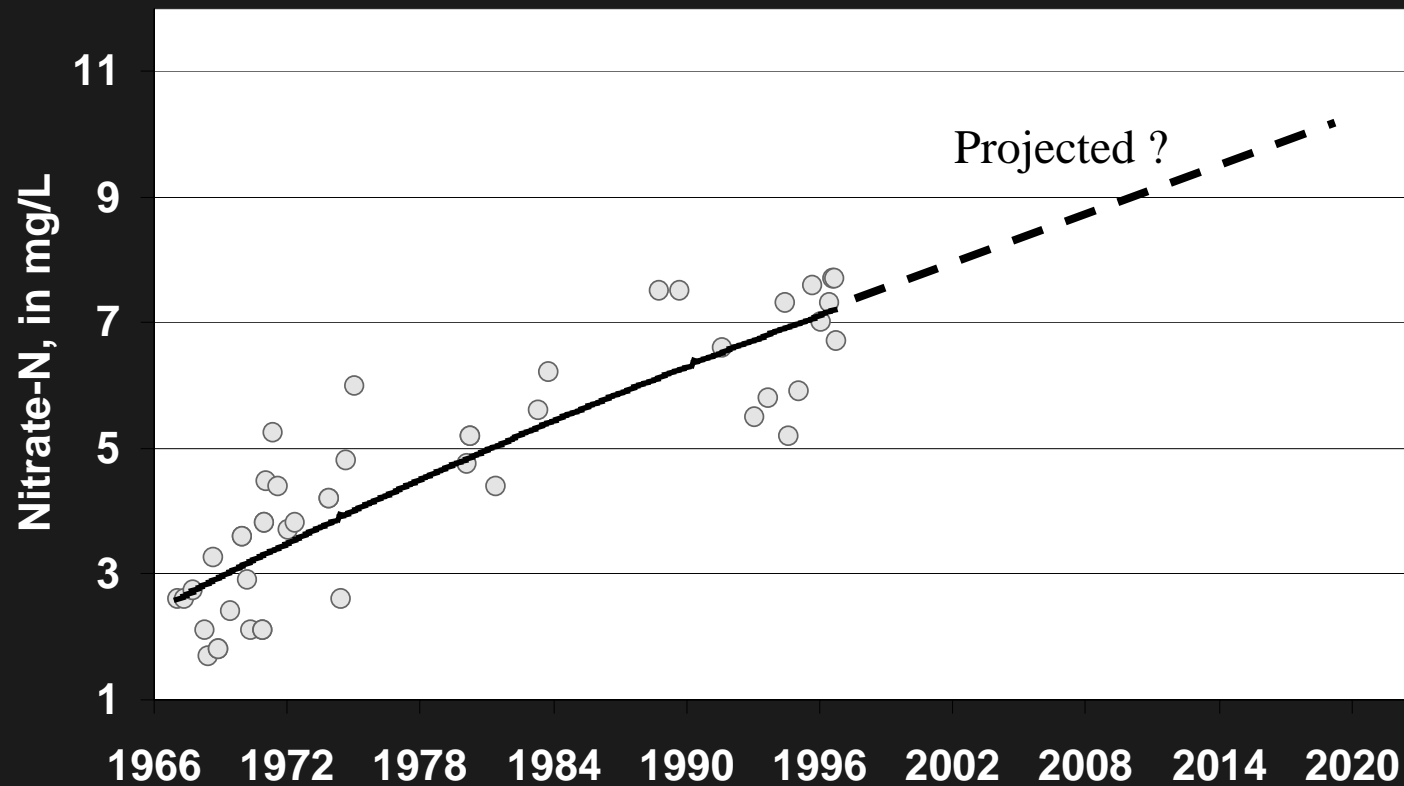
% Nitrate Exceedences:



Whiting nitrate-N; 1963-94



Little Plover River Baseflow nitrate-N; 1966-97



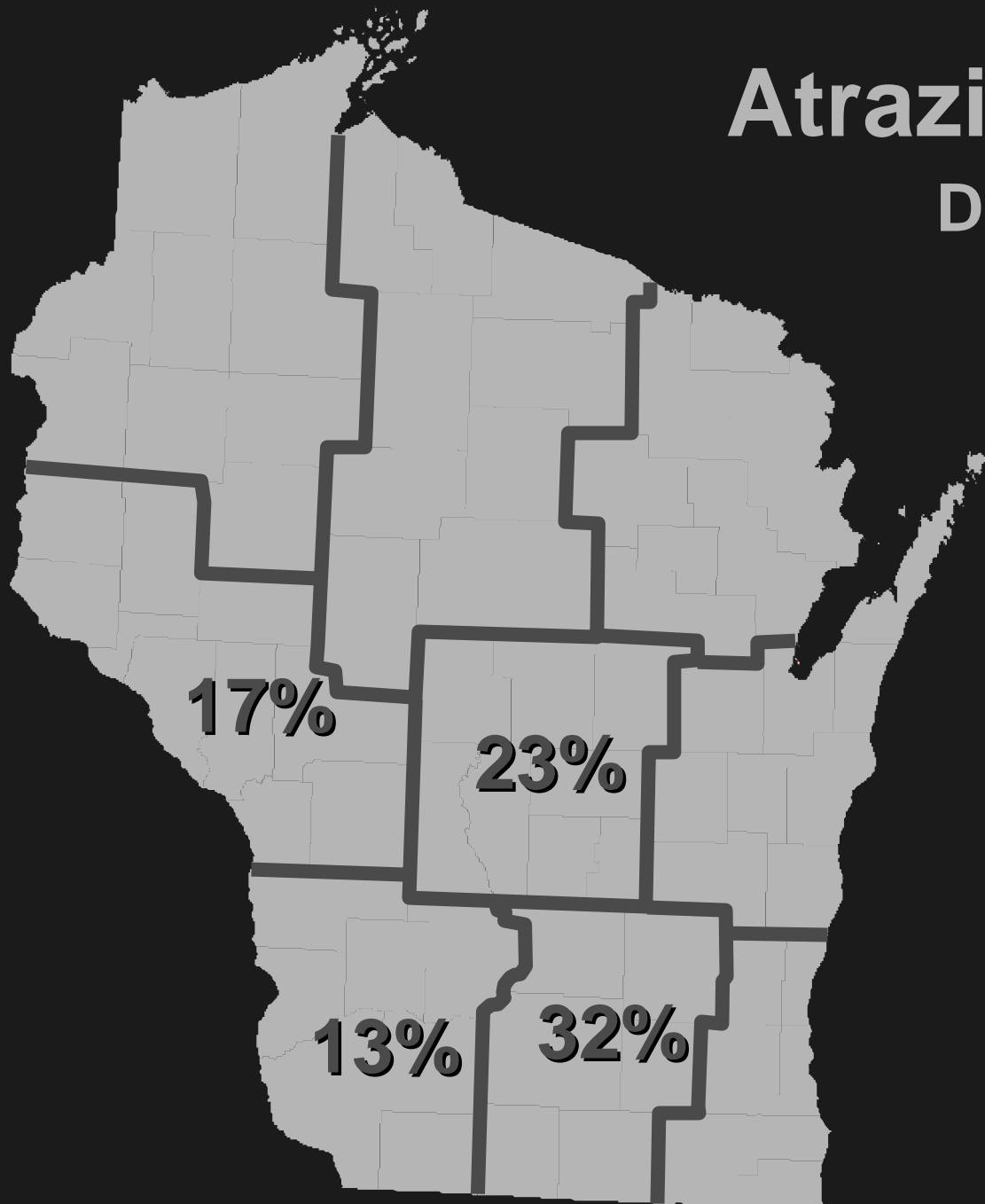
Pesticides

- In the past only Atrazine and Alachlor were extensively surveyed.
- Types of pesticides in use changes rapidly.
- Frequently pesticide degradates not known or are not subject to existing methods of detection



Atrazine Detections

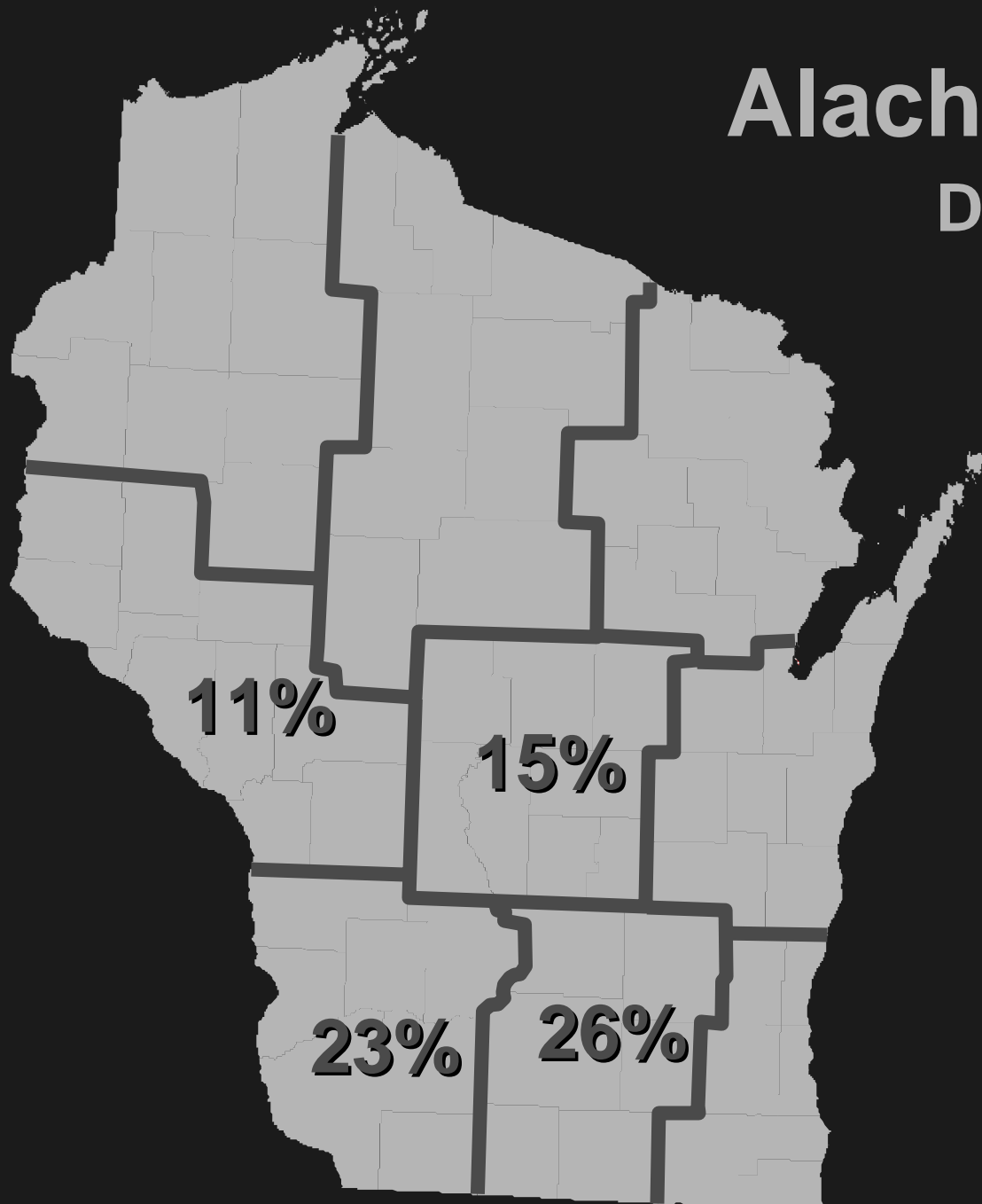
Domestic Wells



(Lemasters and Baldock, 1997)

Alachlor Detections

Domestic Wells



(Lemasters and Baldock, 1997)

Pesticide Detection in Wisconsin Wells

- 1995 – **14%** contain at least one pesticide residue, atrazine or alachlor (Lemasters and Baldock, 1997).
- 2000 – **38%** contain at least one pesticide. Chloroacetanilide metabolites are most prevalent. Proportion greater in agricultural districts (Rheineck, oral communication, 2001).

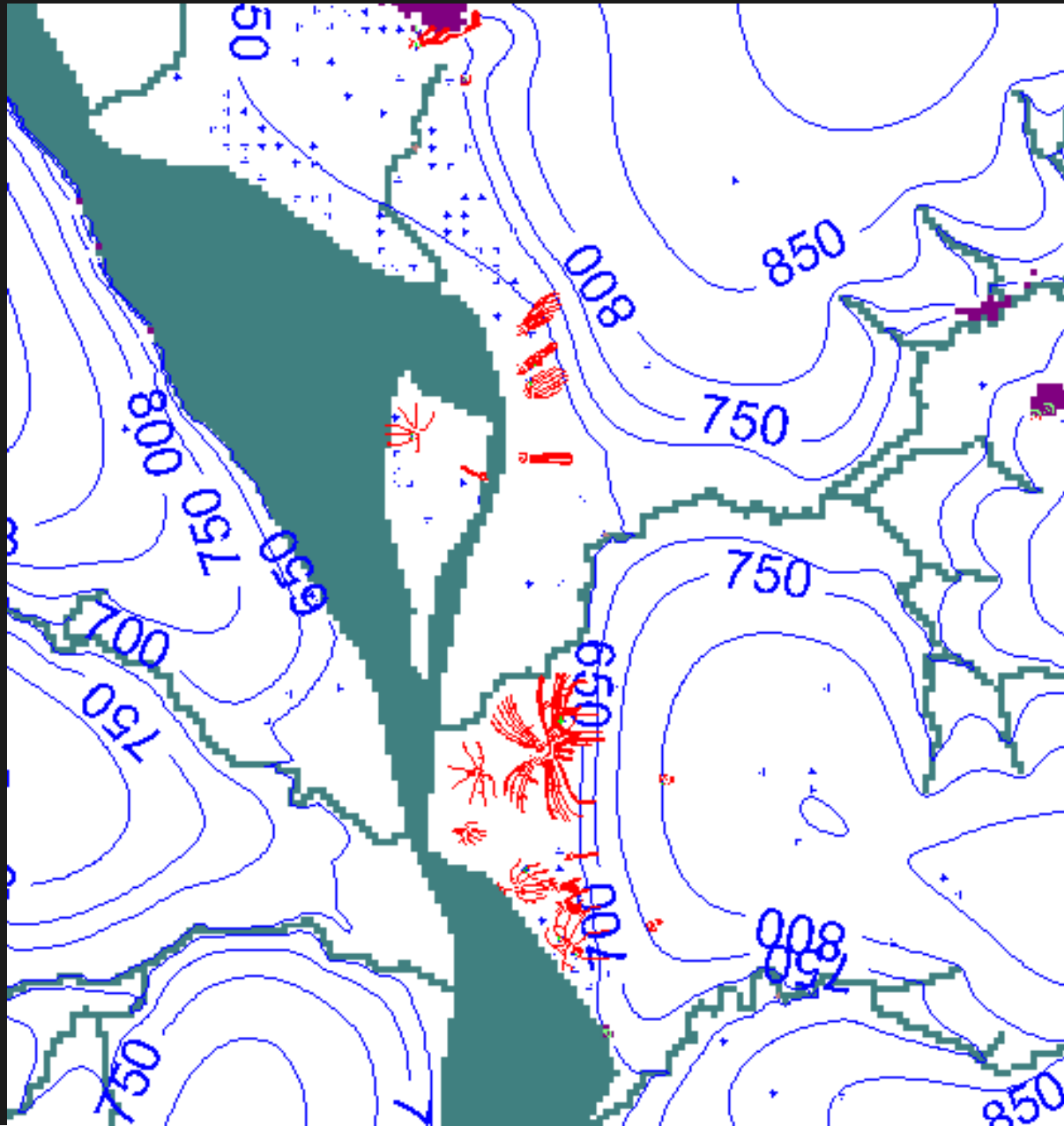
Emerging Contaminants - Viruses, Pharmaceuticals, Endocrine Disruptors



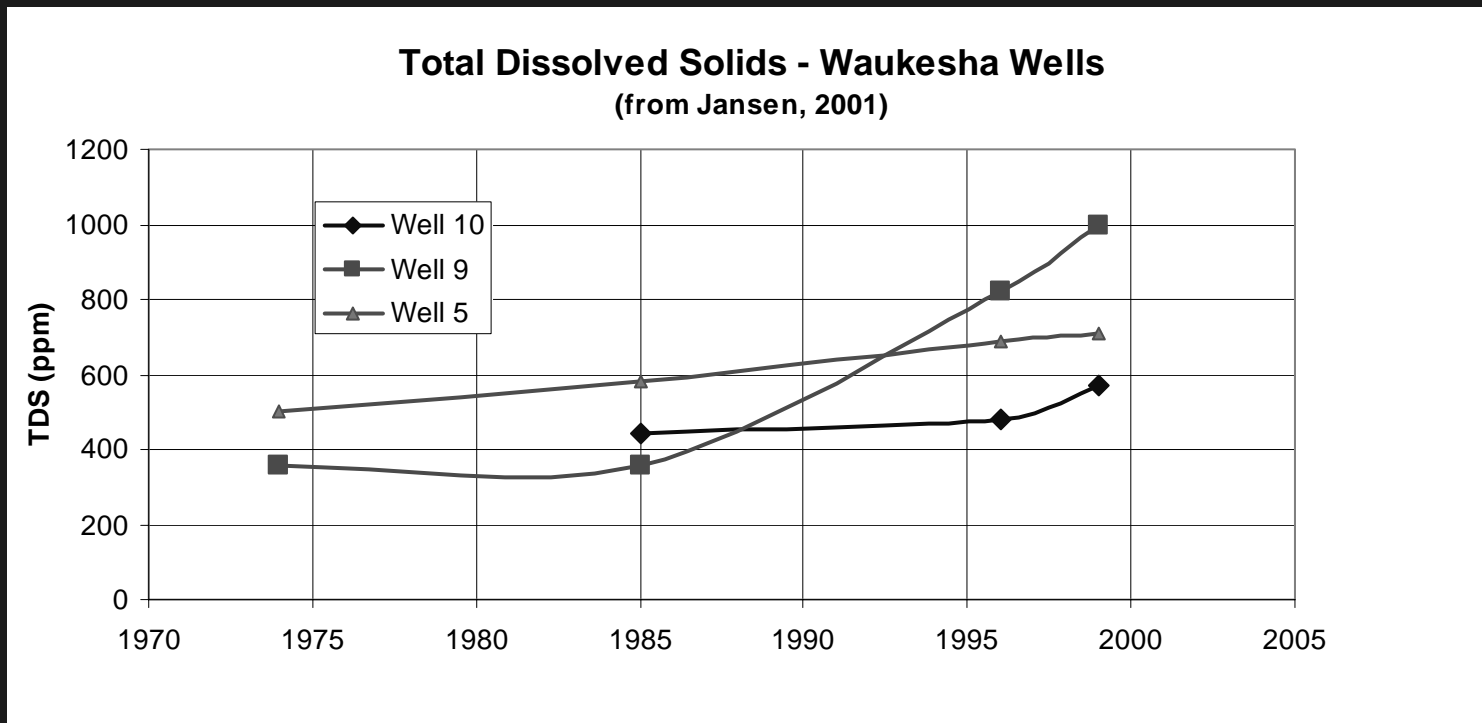
LaCrosse County Hydrologic Study

- Groundwater flow model indicates that some city of LaCrosse Wells withdraw water from the Mississippi River
- Selected wells tested for enteric viruses and endocrine disrupters

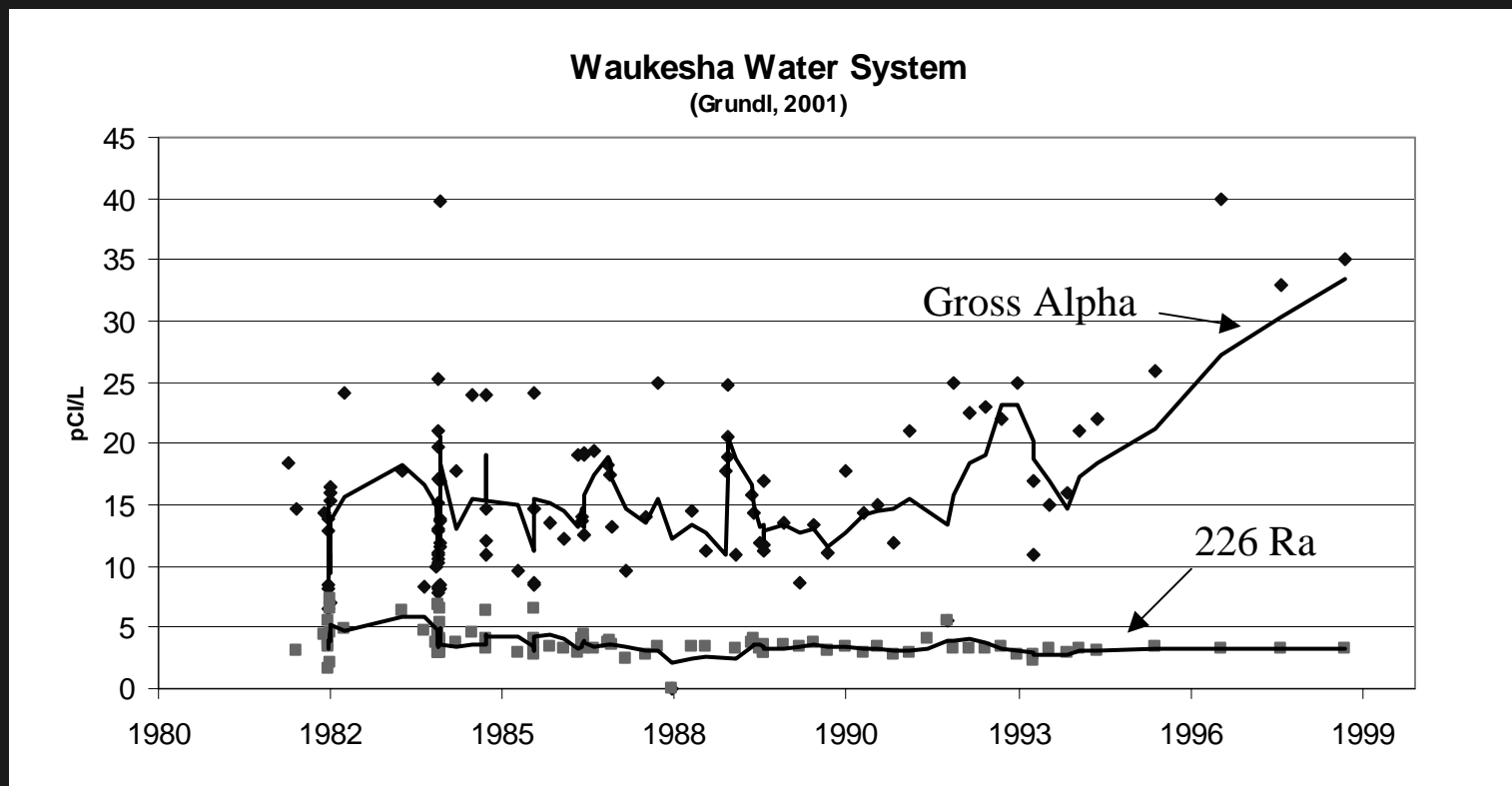
Pathlines—La Crosse Municipal Wells 10-year time of travel



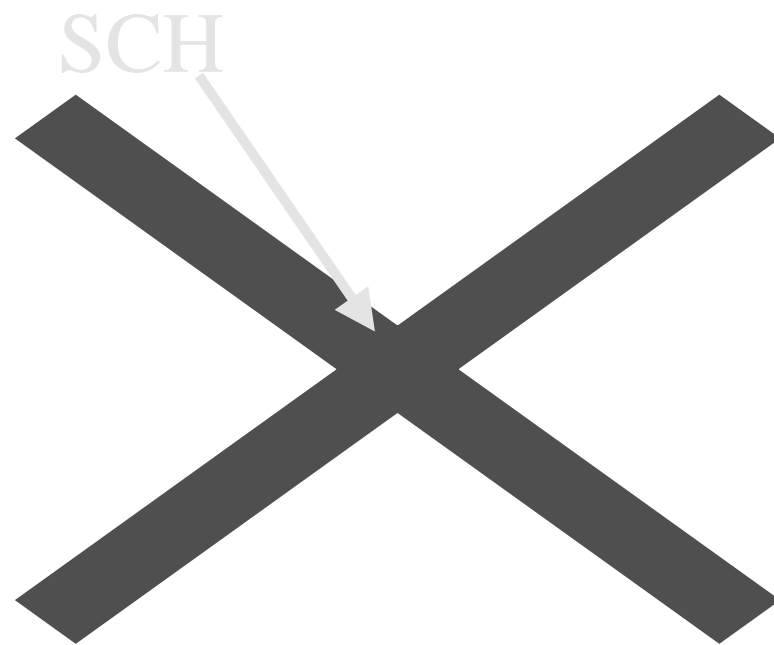
Total Dissolved Solids Sandstone Aquifer – SE WI



Radioactivity in Sandstone Aquifer – SE WI

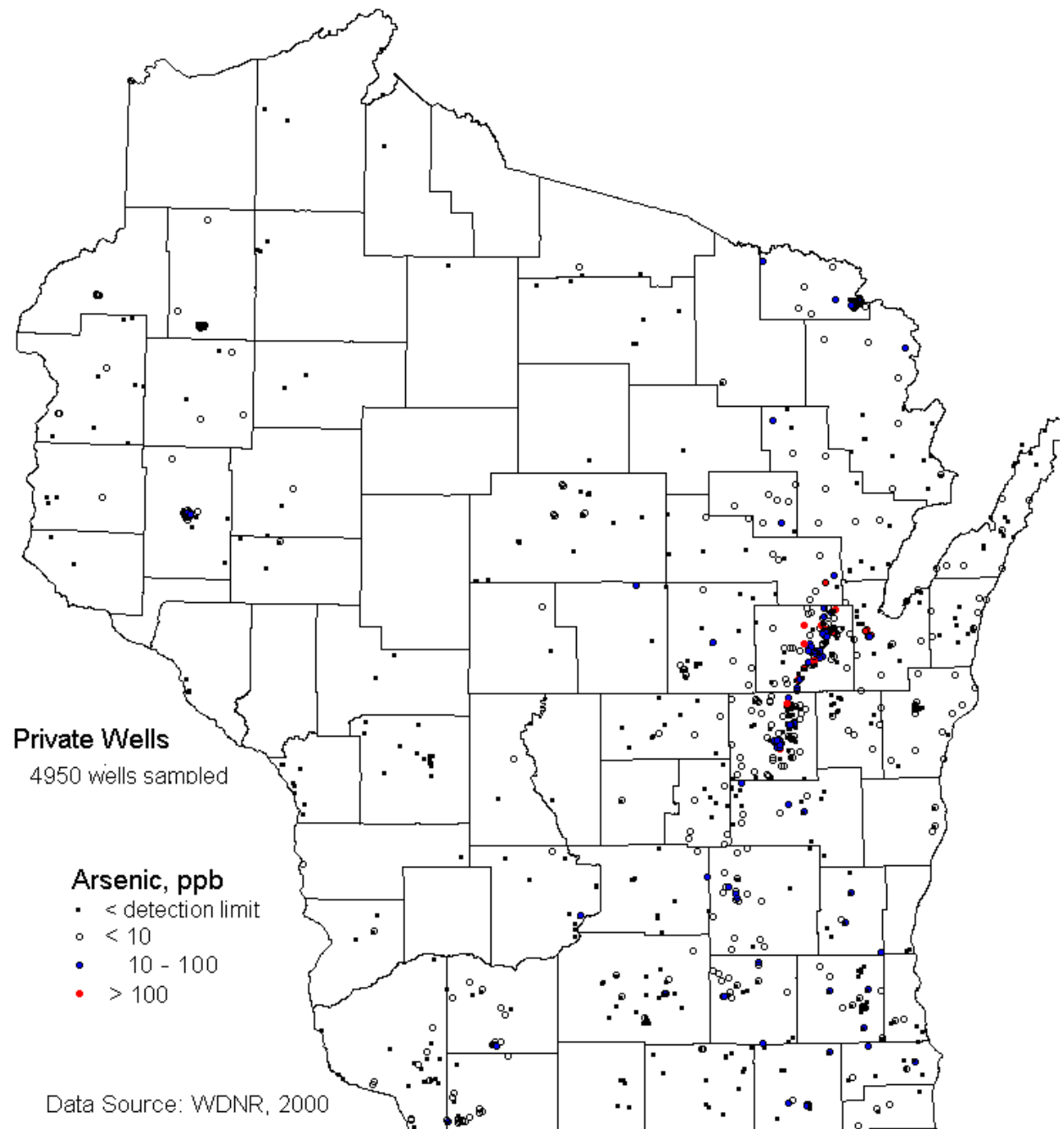


Arsenic



Outagamie & Winnebago Counties:

- As >10 $\mu\text{g/L}$ in 18% of residential wells
- As > 50 $\mu\text{g/L}$ in 3.5% of residential wells



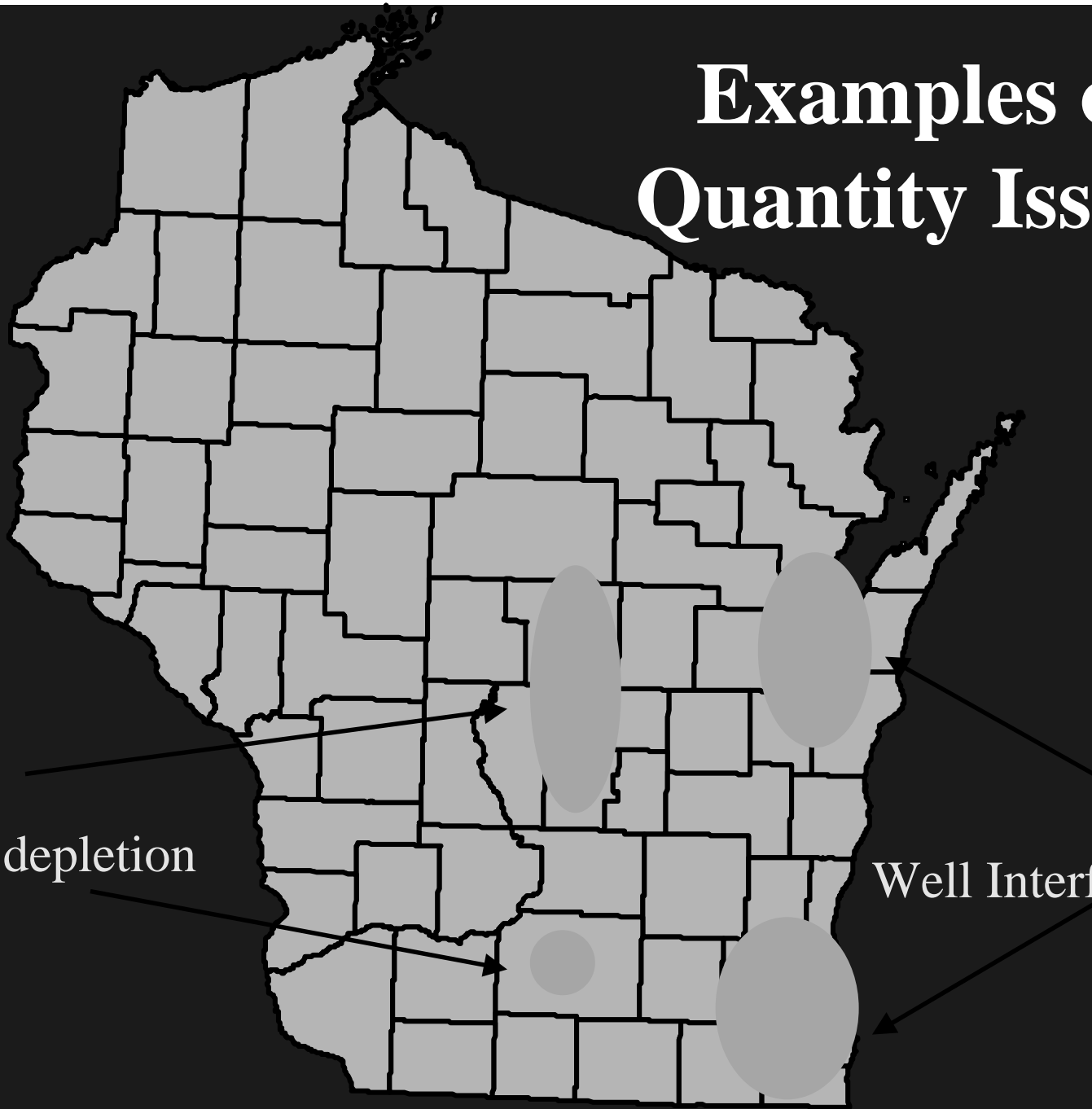
Groundwater Quantity Issues

- Unacceptable drawdown due to well interference (Regional, large scale, deep aquifer).
- Undesirable depletion of baseflow and unwanted drying of wetlands (small and large scale, deep and shallow aquifers).

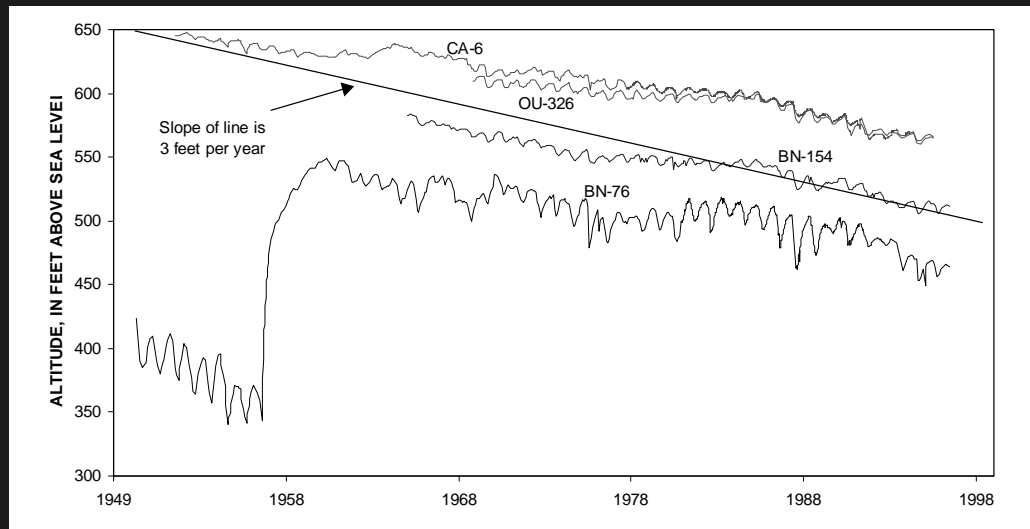
Examples of Quantity Issues

Baseflow depletion

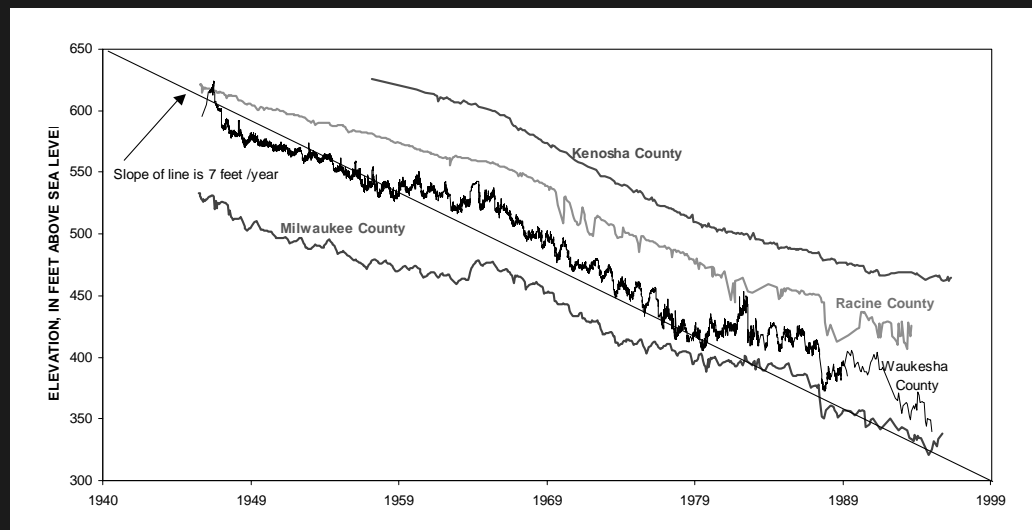
Well Interference



Lower Fox River Valley (3 ft/yr)



Southeast Wisconsin (7 ft/yr)



Lower Fox River Valley



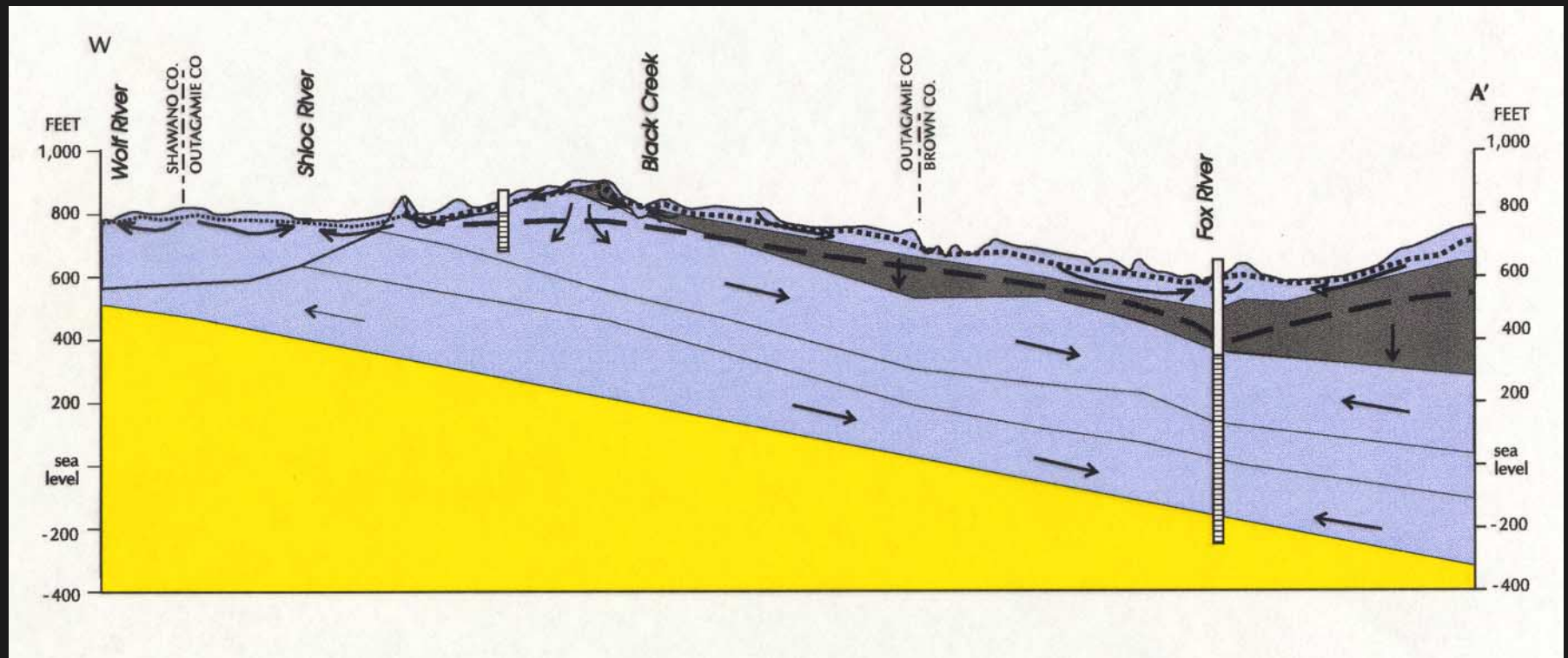
Unacceptable
drawdown due
to well
interference
(Regional, large
scale, deep
aquifer)

“Water, taken in moderation, cannot hurt anybody” *Mark Twain*

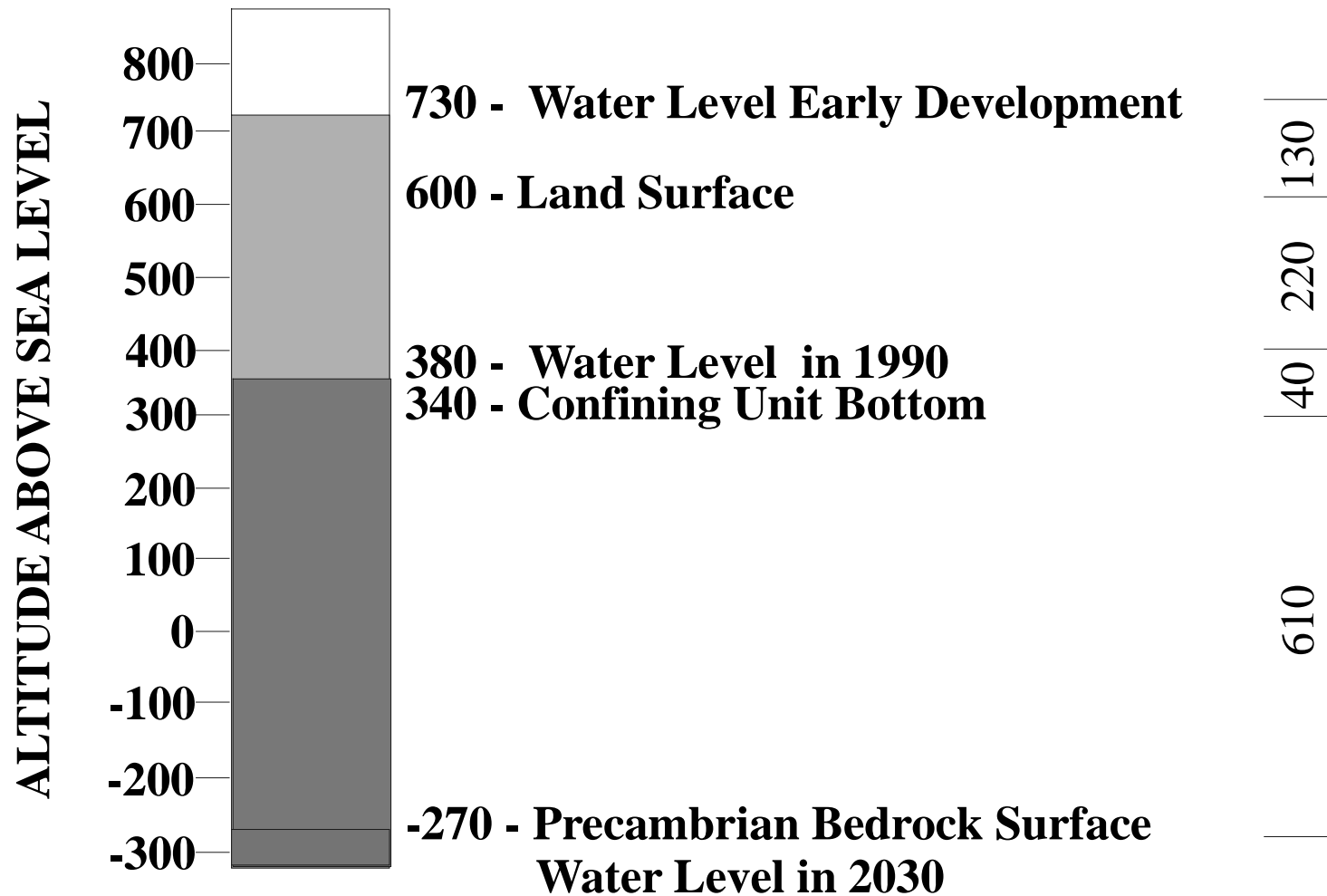
GB 96,000

Metro area 80,000

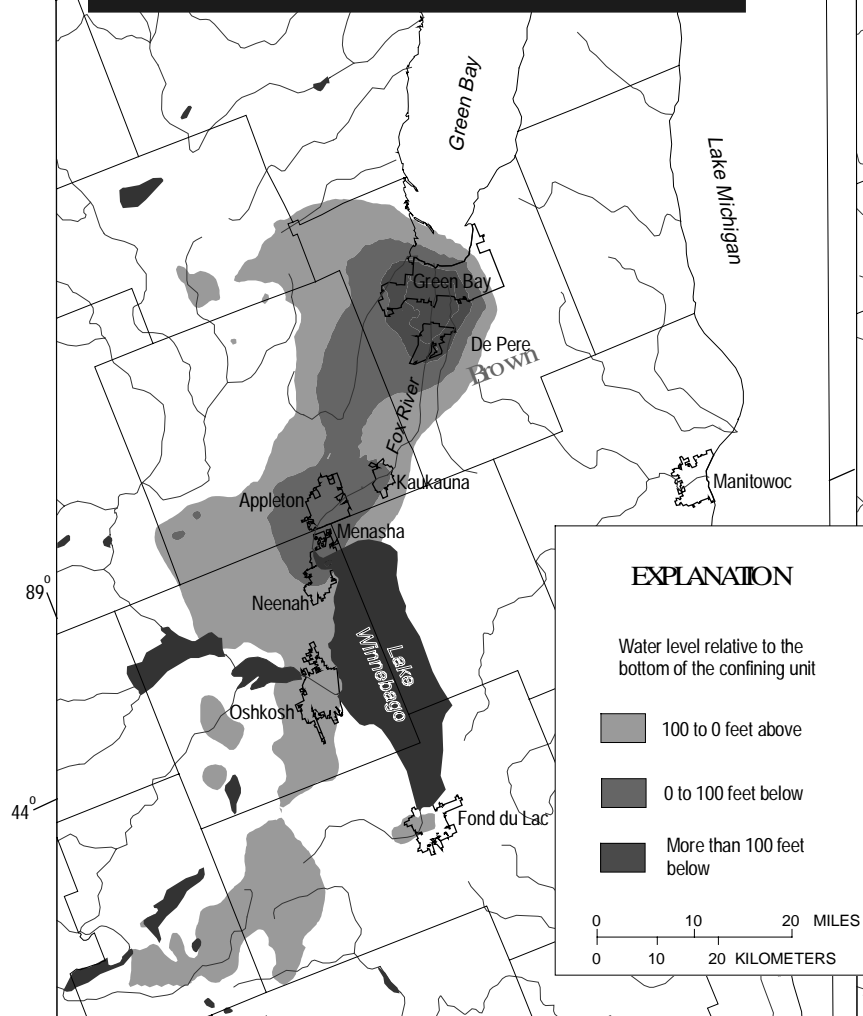
Lower Fox River Valley Conceptual Model



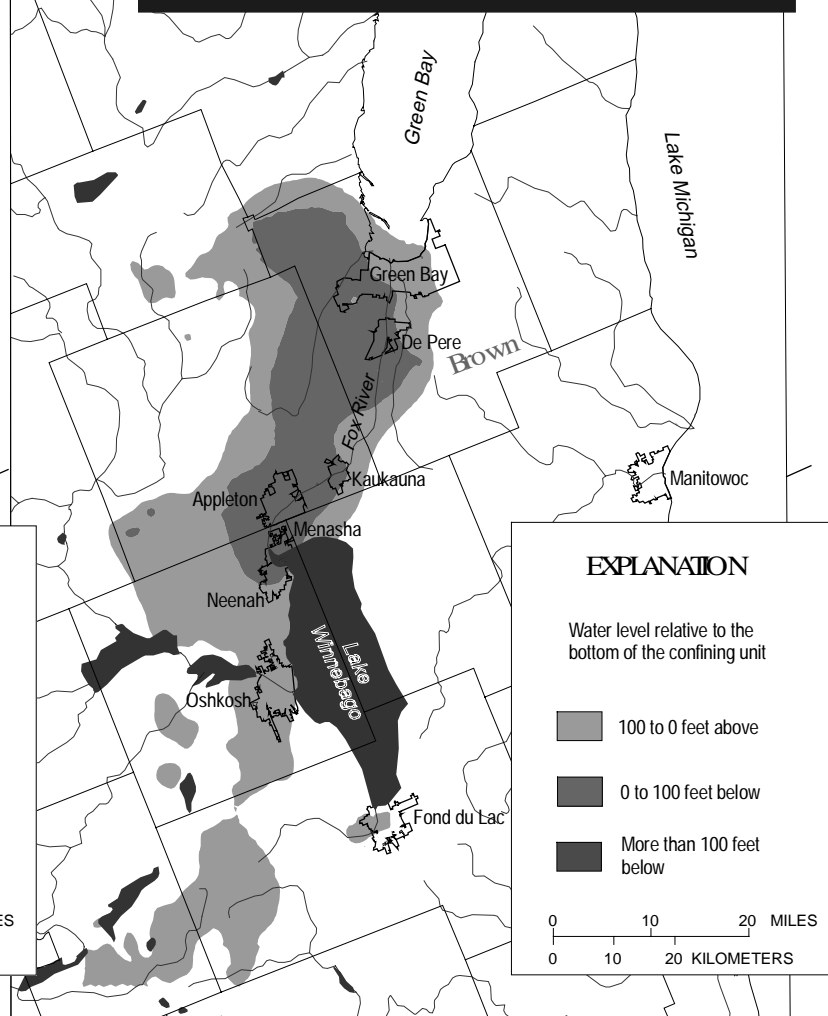
Green Bay Metropolitan Area



Before Optimization

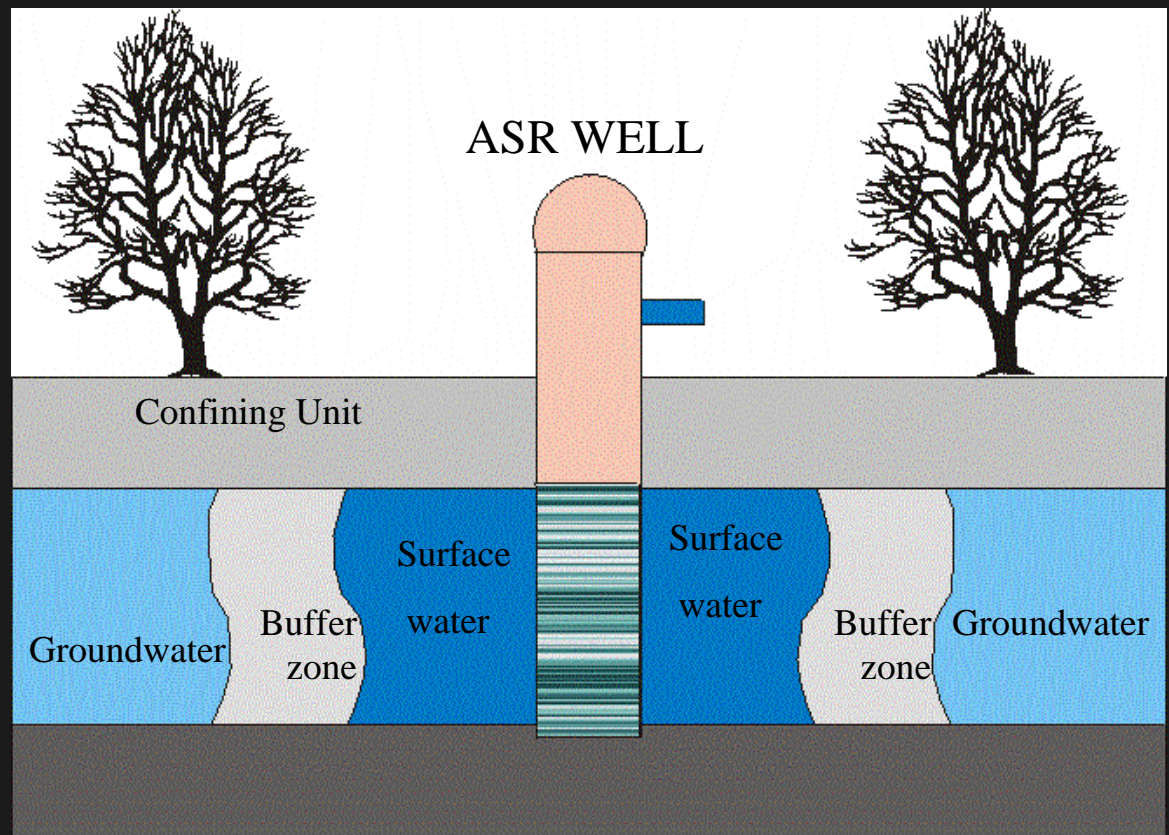


After Optimization

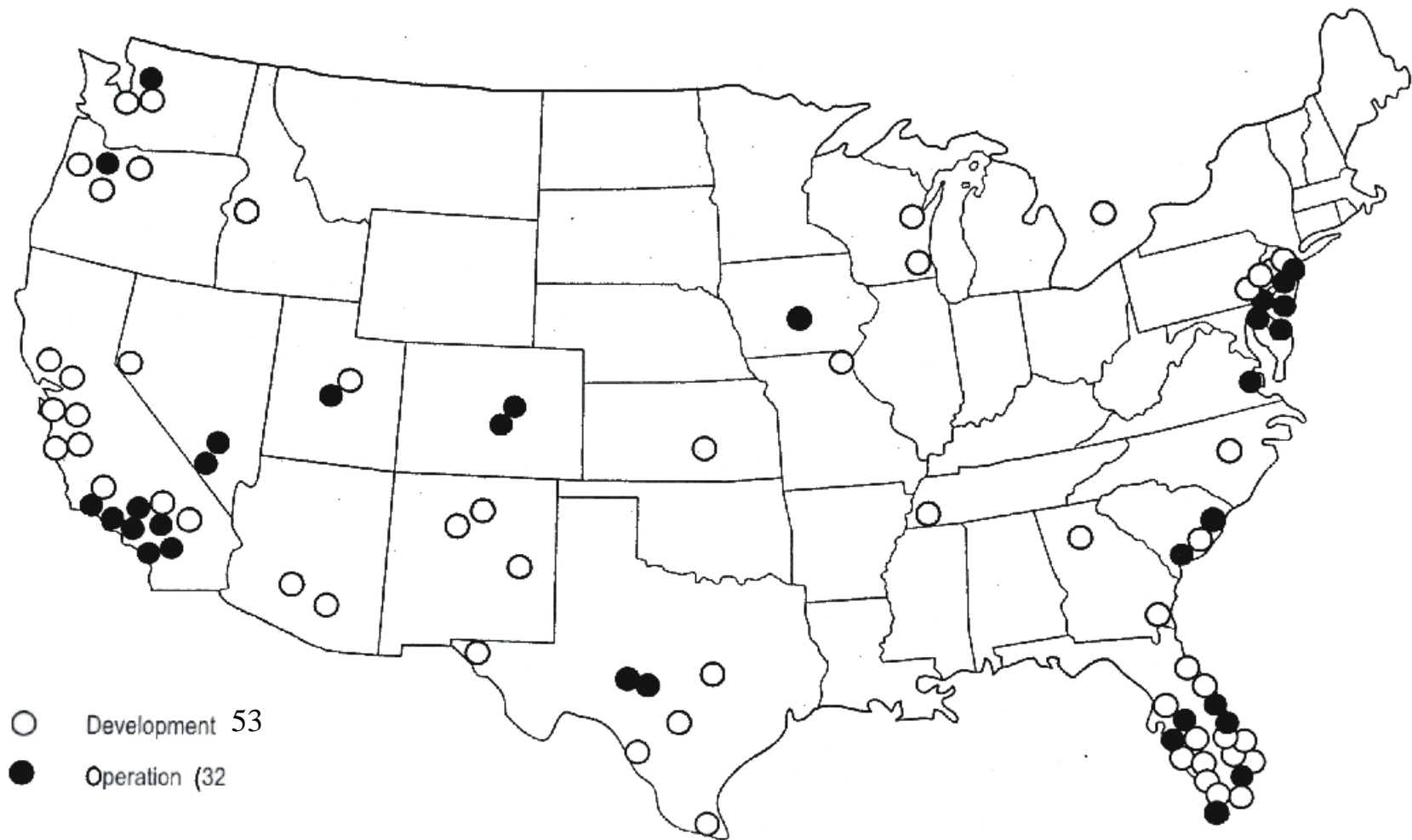


- Treated surface water is injected into a well and recovered at the same location (ASR wells)
- Injected when excess capacity is available at water treatment plant
- Storage – Seasonal and long term

Aquifer Storage and Recovery



ASR Facilities in the United States



From CH2M Hill, Feb 1999

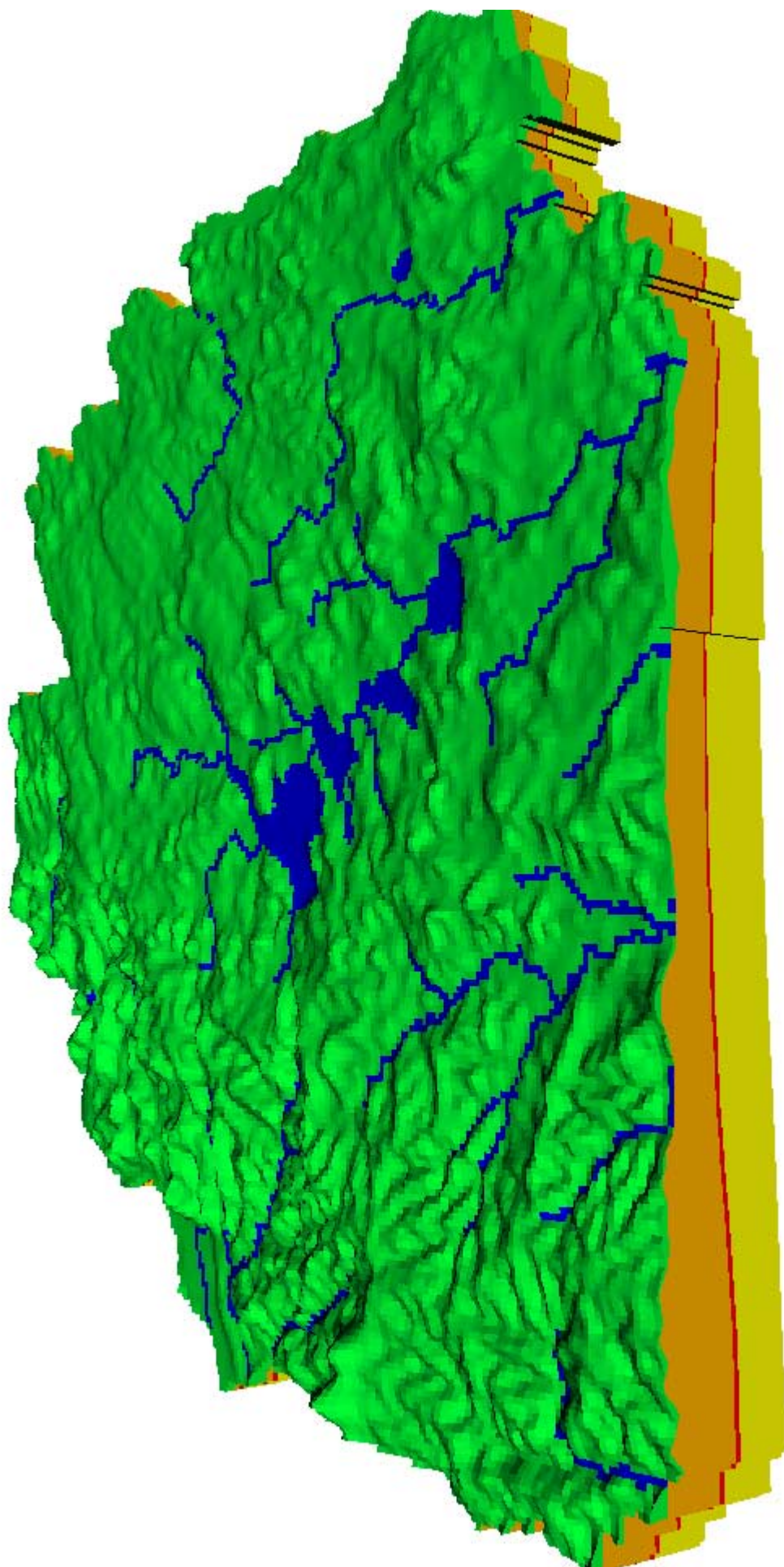
Central Brown County Water Authority Management Alternatives

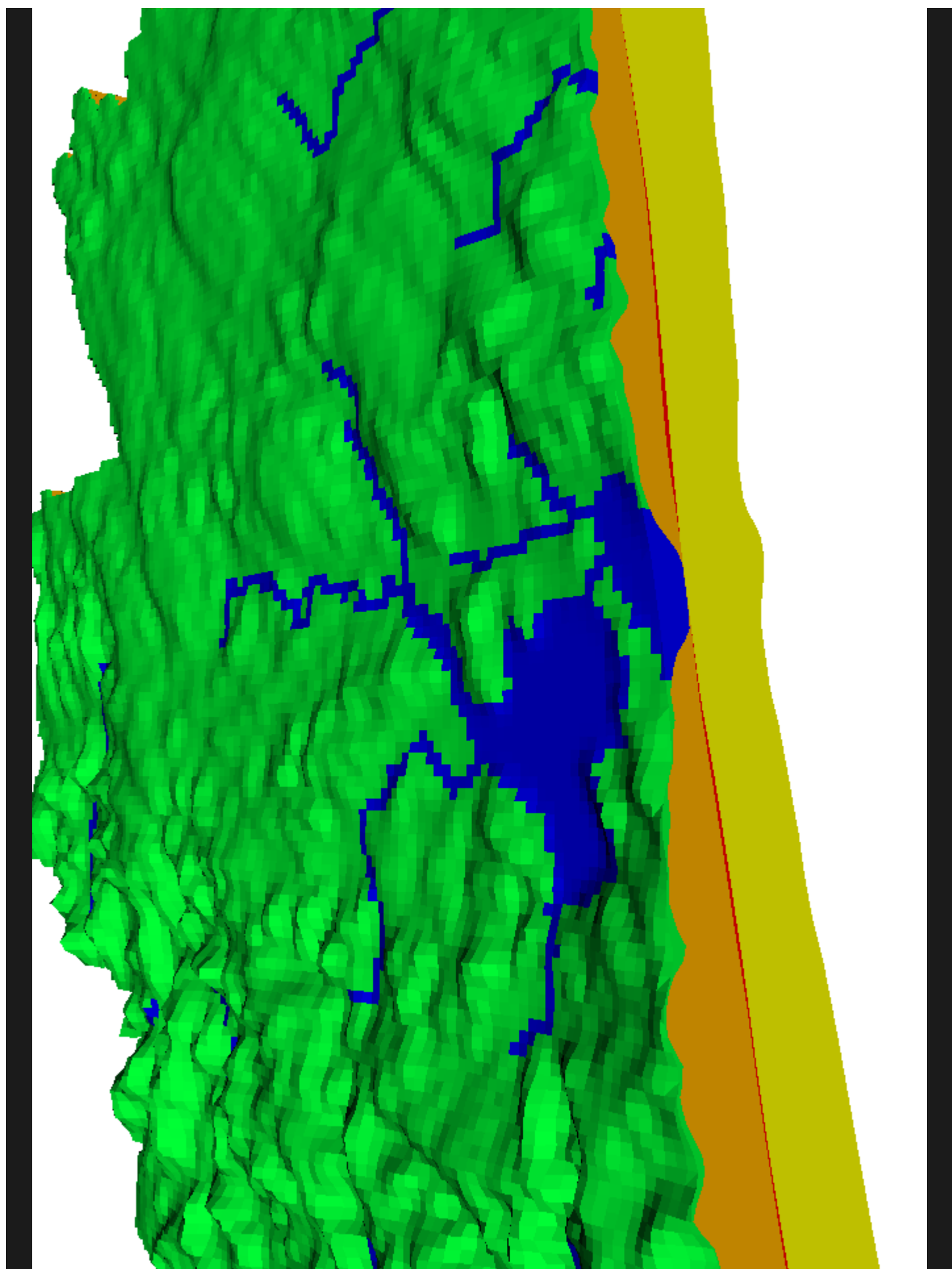
- Build independent Lake Michigan water supply system (\$132 million)
- Buy water from Green Bay Water Department and use ASR in 19 existing wells
- Optimize ground-water withdrawals
- Combinations

Dane County

**Undesirable
depletion of
baseflow and
unwanted
drying of
wetlands
(large scale,
deep aquifer).**







▲ Groundwater discharge to surface water

▼ Surface water discharge to groundwater

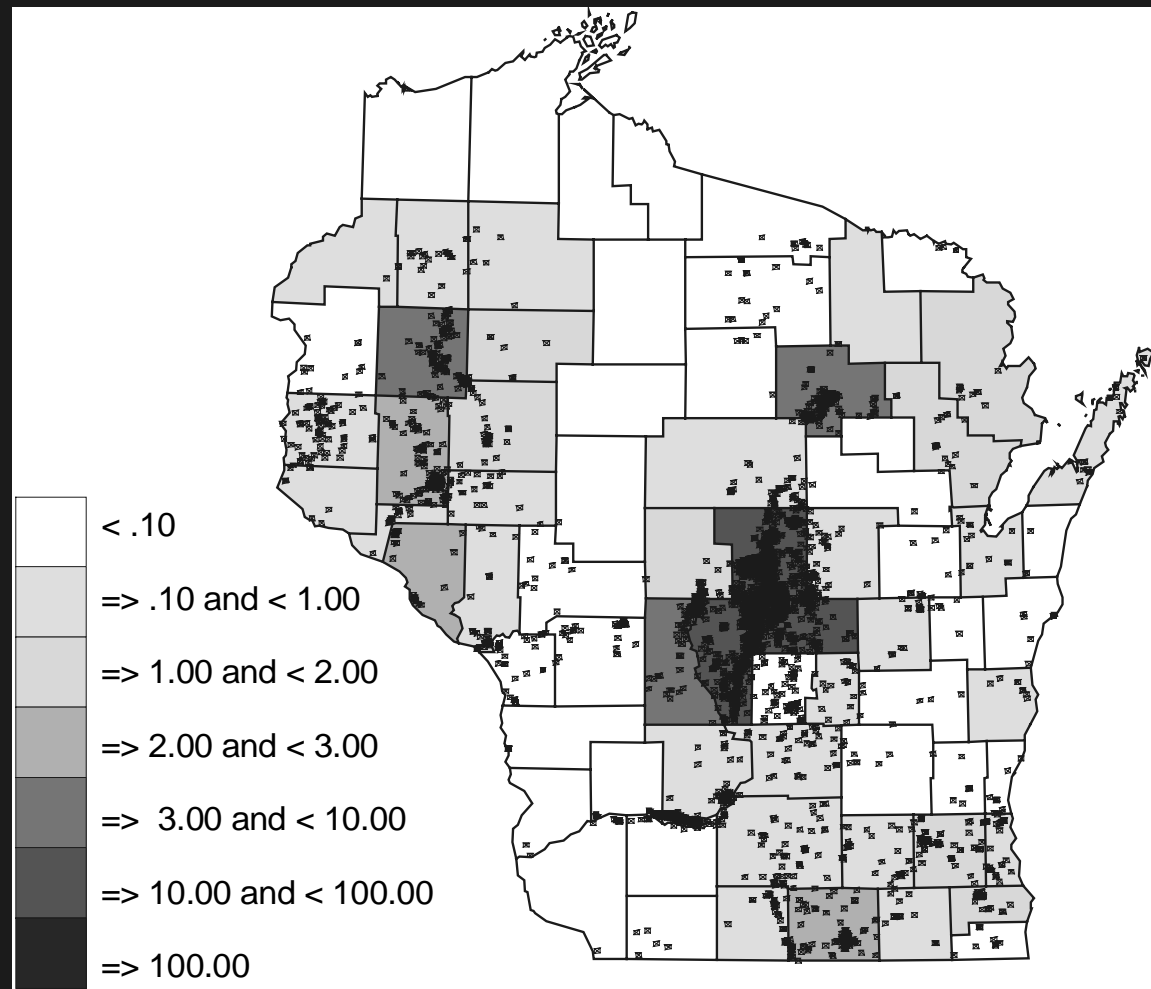


Agricultural Irrigation

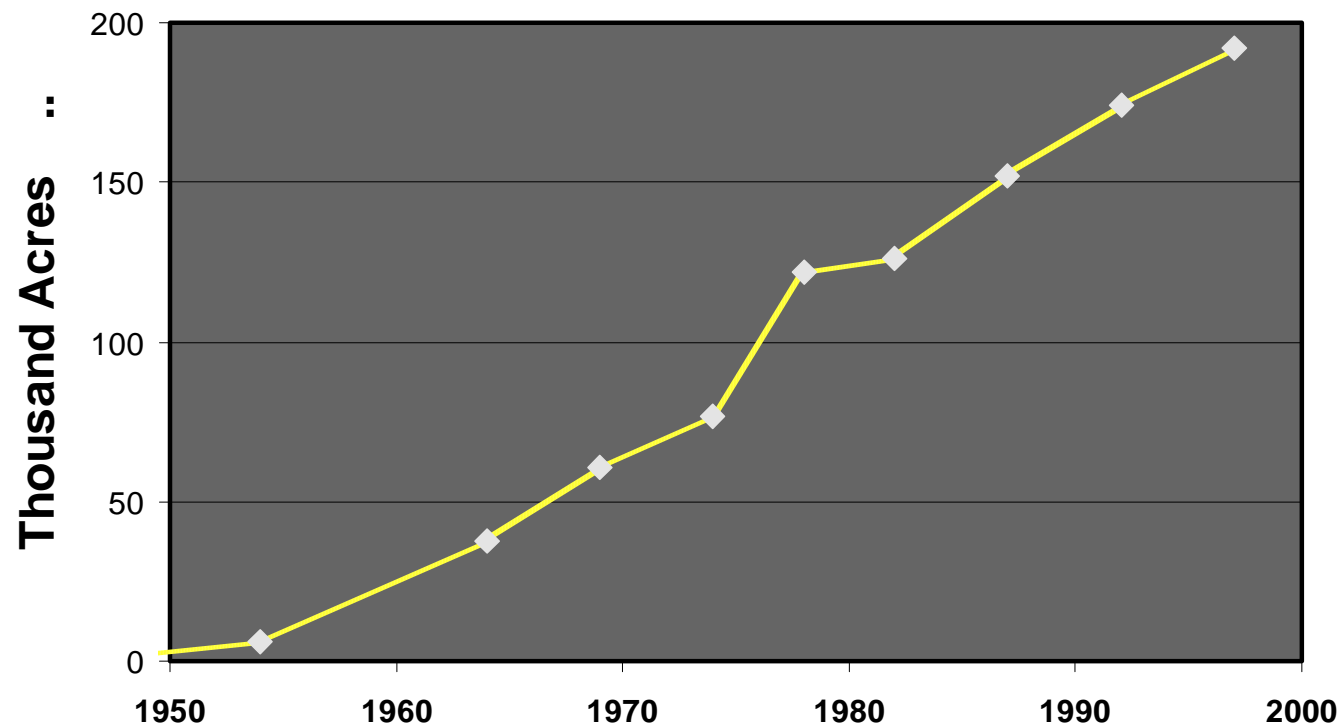


Undesirable depletion of baseflow and unwanted drying of wetlands (small scale, shallow aquifer).

Agricultural Irrigation 1995



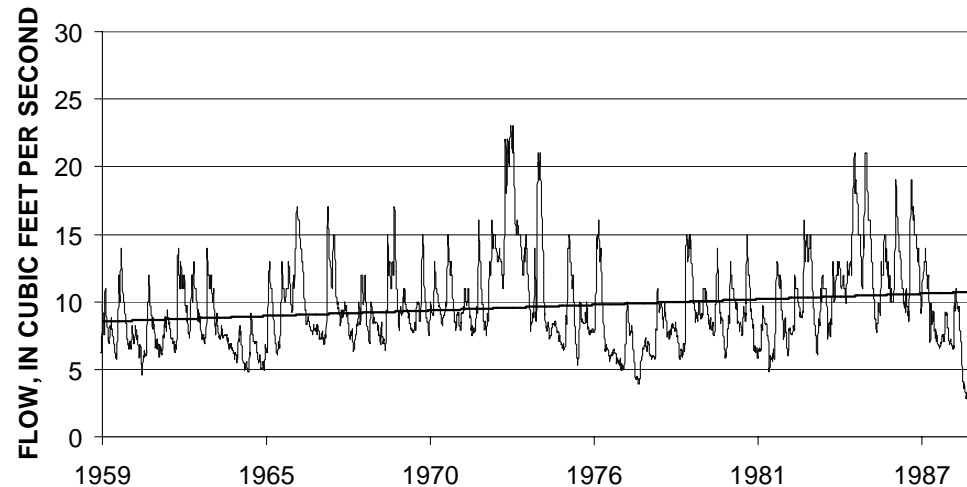
Central Wisconsin Irrigated Acres



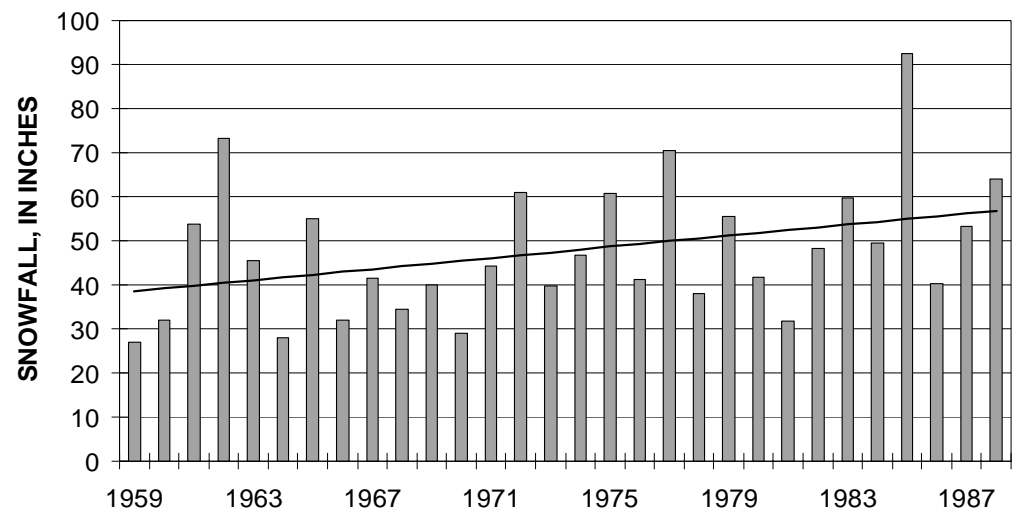
- Baseflow (1959 – 88) has not decreased

- Snowfall amount (1959 – 88) has increased

**Base Flow Little Plover River at Plover Wisconsin
05400650**



Snowfall Hancock Wisconsin



Concluding Comments

- Regional Management
- Pumping wells are optimally spaced to reduce drawdown, preserve water quality and protect highly-valued resources
- Appropriate land application rates of fertilizers and pesticides
- Collection of streamflows and groundwater levels